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THE UNIVERSITY OF ILLINOIS

MECHANICAL ENGINEERING

New Packard Laboratory, Lehigh University

October 1930

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Men, Money, and Machinery

THESE, crudely, are the elements of our civilization. The problems of human relations, of finance, commerce, and economics, of science, engineering, and technology, concern all of us. As engineers we take pride in the rapid and sure advance which technological developments have made and the benefits they have brought, but we are likely to be impatient with progress in the equally important fields devoted to humanistic affairs. Our progress has outstripped man's capacity to make intelligent use of it, we sometimes feel.

The way of salvation, if there be any, lies in coordinating the elements, men, money, and machinery, and adapting them properly to the solution of the major problem, which is civilization itself and the satisfactions in things and values for which men yearn. Engineers cannot do this alone, nor can economists, or sociologists, or any other group of specialists. But instead of passing on to other groups the responsibility for solving the tremendous problem of bringing man to a complete control of his life and environment, each must recognize the opportunity which exists for concerted action and the obligation which confronts all. Without assuming roles we are not fitted to fill, let us bring to others who have a special knowledge and different viewpoints the benefit of our own special knowledge and viewpoint with the hope that by combined effort progress may be accelerated. It is time for all intelligent specialists to cooperate for the common welfare.

MECHANICAL ENGINEERING

Volume 52 October, 1930 No. 10

A New Engineering Laboratory

A Description of the James Ward Packard Laboratory of Electrical and Mechanical Engineering at Lehigh University, and of the Principles Involved in Its Design and Construction, and Operation

By F. V. LARKIN[1] and S. S. SEYFERT,[2] BETHLEHEM, PA.

ON OCTOBER 15, 16, and 17, 1930, Lehigh University will dedicate the James Ward Packard Laboratory of Electrical and Mechanical Engineering. This building, probably the finest of its kind ever erected, stands as a memorial to James Ward Packard, an alumnus of the University, founder of the Packard Electric Company and of the Packard Motor Car Company. The building was conceived and the preliminary plans for it were laid down in 1923. It was designed in 1927, erected in 1928, and first occupied in September, 1929.

F. V. Larkin

S. S. Seyfert

As many of the great laboratories of America, both educational and industrial, were inspected prior to the final design, and because a host of educational and industrial leaders of the country have directly or indirectly contributed to its final form, it seems fitting to make a record of the ideals, the plans, the philosophies, and the methods, that have made the building what it is.

After Dr. Charles Russ Richards became president of Lehigh University in the autumn of 1922, he made a careful and elaborate study of the needs and the possibilities of the University. One of the conclusions of this study was that more room was necessary for the adequate handling of undergraduate work. After a consideration of the advisability of several small buildings or a single large one to meet these needs, the latter alternative was selected as the more desirable, and two of the larger departments, electrical engineering and mechanical engineering, both cramped particularly for laboratory space, were commissioned to design a common building which would adequately meet their needs for a long time to come.

This commission met a prompt and eager response even though no one knew at the time where the funds were coming from. With the number of engineering students which the University can handle fixed by the Board of Trustees at nine hundred, it was not a difficult matter to estimate the number of students in these two departments, the number of instructors necessary to handle them, and the office, classroom, and laboratory space necessary for their adequate accommodation. Thus area and volume requirements were established. Where to locate the building was evident to the designers from the start, although less evident to the general alumni body who deplored the removal of trees and the curtailment of a beautiful vista which the location involved. The material of construction was easily established by adhering to the construction prevailing on the campus—native sandstone.

Preliminary Study of Conditions

A four- or five-story type of building was established by ground limitations, cost, and adherence to the prevailing architecture on the campus. The layout of the building was established more from the consideration of adequate lighting than from the standpoint of expansion or any other consideration. A study of the conventional forms, H, U, L, I, T, E, led to the adoption of a combination of the letters E and I and resulted in a building of the shape of a rectangular figure 8. By making all legs of the E wide enough for two rooms with a single hall between them, the requirement of adequate outside light was met. By extending the walls of the laboratory section slightly beyond the main building, provision was made for easy expansion, if necessary.

The adaptation of the building to the contour of the campus was not so easily established. Quite naturally, the E part of the building should be the higher, containing offices and classrooms, and the laboratory section, by no process of reasoning, need be more than three stories. Thus was evolved a building five stories high, facing the street, with a three-story laboratory in the rear. Since the building was to accommodate two departments, the question of one or two main entrances presented itself. A single main entrance with auxiliary side entrances was decided upon as better architecturally and cheaper.

At this stage in the development, with form and dimensions established, a model of the building was made to establish its conformity to the contour of the building site which has a natural

[1] Director of Industrial and Mechanical Engineering, Lehigh University. Mem. A.S.M.E. Professor Larkin received the degree of B.S. from the University of Wisconsin in 1906 and the degree of M.E. in 1915. From 1906 to 1919, with the exception of a period, 1912–15, when he was an instructor at Lehigh, Professor Larkin was engaged in engineering work with several power and manufacturing companies. He returned to Lehigh in his present position in 1919.

[2] Professor of Electrical Engineering, Lehigh University. Professor Seyfert was educated at Lehigh where he received the degrees of E.E. in 1904 and M.S. in 1909. He has been teaching at Lehigh since graduation and became acting head of the department of electrical engineering in 1928. For a period of twenty years he has been engineer, and more recently secretary-treasurer, of the Blue Mountain Electric Company. He is a member of the A.I.E.E.

slope of one foot in ten. The result of this model study was far-reaching, inasmuch as it revealed the wisdom of turning the building entirely around. This made available a high, light basement floor, easily accessible from the street for trucks. It very greatly reduced the amount of excavation and the consequent removal of trees. It effectively completed a quadrangle effect in conjunction with other buildings on the campus, and it placed the main entrance on the third floor, thereby locating the main offices, on campus level, precisely in the vertical center of the building, a feature which has proved to be a great operating advantage.

transfer of stock in that amount. Thus in the spring of 1927, the building became a certainty and arrangements were made to work over the original plans and to make such revisions as might develop.

The situation was unique. There was a pressing need for an engineeering building with laboratory facilities. There was an adequate fund available. Plans were well in hand. President Richards, as a former professor of mechanical engineering, dean, and director, had built two laboratories, one at the University of Nebraska where funds were limited, and one at the University of Illinois where an old building had to be utilized.

FIG 1 THE JAMES WARD PACKARD LABORATORY OF ELECTRICAL AND MECHANICAL ENGINEERING, LEHIGH UNIVERSITY

With size, shape, form, and location established, each of the two departments proceeded to dispose of the space allotted to it in the form of offices, lecture rooms, classrooms, research rooms, laboratories, etc. At this point, designs and plans were turned over to the architects who enclosed the space detailed, provided the architectural features, and brought out the design of the building to conform to the space requirements specified.

SECURING THE NECESSARY FUNDS

In 1926 the University sent to its alumni an attractively prepared bulletin setting forth the need for an engineering laboratory and including the plans as developed. Mr. Packard was interested at once. After a prompt survey by his secretary, he requested and was given an option on handling the entire project. Ill at the time, Mr. Packard closed the negotiation by sending the University a promisory note for one million dollars, pending the

Here was a project new from the ground up and funds to make it a reality.

WORKING OUT THE DETAILS

Prior to reworking the original plans, a traveling party was organized to inspect some of the finest educational and industrial laboratories in America to gain ideas and to furnish a groundwork both as to what it might be well to do and what to avoid.

Following these trips of inspection, active work on the final detailed plans was inaugurated. Each of the two departments was charged with the disposition of its own space and with responsibility for such items as were peculiar to it for the entire building. The departments worked independently on items peculiar to themselves. For considerations involving both departments, frequent meetings were held. Here were decided such matters as concerned general policy—an engineering library

in the building, one or more repair shops, reading rooms, lounging rooms, furniture, lighting, crane service, and the like.

From the start there had been an assumption that the new building would house a branch of the main University library, under the direction of the librarian of the University. This idea did not prevail. The University library building has since been remodeled and increased to five times its former capacity. This building is just across the drive and a little to one side of the laboratory, making a substation in the new building quite unnecessary. Both departments, have, however, provided reading rooms where students may study between classes or look over current technical publications that are available. Both departments have dedicated their reading rooms to the memories of the first department heads—the electricals to Prof. William Esty, who died in 1928, shortly after the building came under construction, and the mechanicals to Dean Joseph Frederic Klein, first professor of mechanical engineering from 1883 to 1918.

No lounging or browsing room was provided in the building, such a room being under contemplation for the library addition, since completed, and because of the proximity on the campus of Drown Memorial Hall, the students' center and recreation building. Provision was made, however, for a smoking room, where students are free to lounge and smoke. This room is dedicated to the use of student societies and serves as a place to hold informal gatherings.

Engineering curricula at Lehigh are unique in that they have never included instruction in shop work. With the advent of the new laboratory this project came up for consideration again, and while all but one of the five men involved had been educated in colleges where shop work was a part of the curriculum, it was readily decided to continue the policy of the institution and provide no student shops. The University has always maintained a close relation with the splendid manufacturing establishments in the vicinity and it has used and continues to use these facilities as a supplement to its own laboratories. While modern industry would seem to dictate one common repair shop for both departments housed in the building, after due consultation and deliberation, two adequate shops with separate staffs were provided. Standard tools have been duplicated in the two shops. Special tools have been acquired on a complimentary basis so that one shop or the other can accommodate almost any kind of work which may come to the mechanicians.

Thus, after careful study, complete final plans were evolved. Mr. Packard was pleased. To make certain that there should be no necessity of curtailment in the building and its equipment, he, at this time, added two hundred thousand dollars to his original gift. As a result of the careful planning, the contract for the building was executed within fifteen months with practically no changes in plan or increase above the contract price.

Deliberate and careful procedure resulted in a maximum service

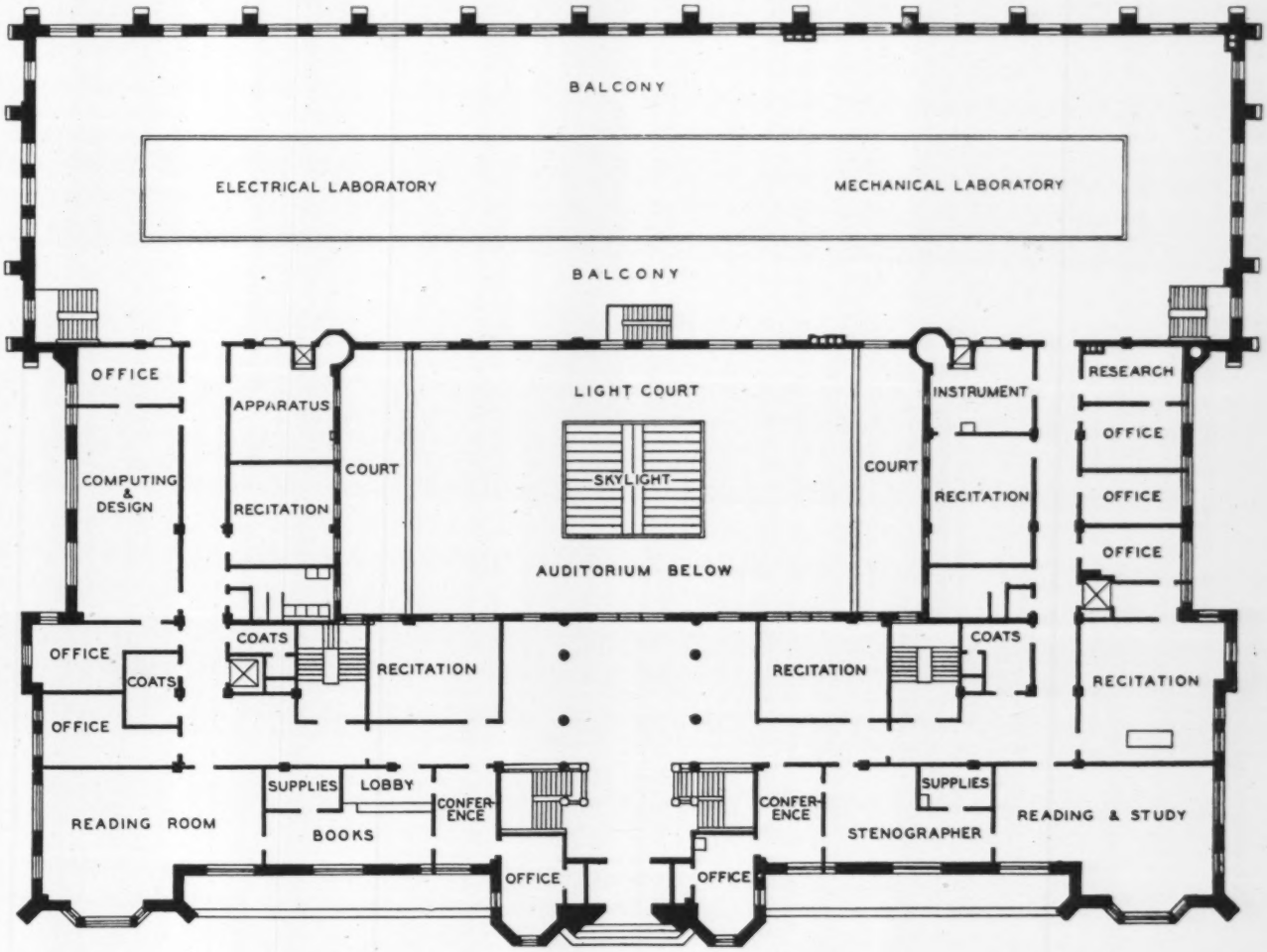

FIG. 2 PLAN OF THIRD FLOOR, PACKARD LABORATORY, SHOWING LABORATORY GALLERY AND MAIN ENTRANCE FROM CAMPUS

of such facilities as truck entrance, lifting hatch, traveling crane, auditorium seating 622—the largest on the campus—student smoking room, general toilet and coat-room facilities, five entrances with stairways, two elevators restricted to departmental use, and ventilating equipment as necessary. Effective provision has been made to confine laboratory noises and odors to the laboratory section. In addition, this procedure has resulted in a number of special features: No coats hang in the halls of this building. Wherever there is an assembly of students, a coat room is provided off the main corridor; laboratory floors were poured solid and a Calyx drill was used for openings for exhaust pipes and electric conduits; laboratory machines of the smaller commercial sizes were adopted on the ground that a wider range could be provided in the given space at less cost, both initially and from the standpoint of operation and because it is deemed better laboratory teaching practice to permit students to operate units very largely on their own responsibility; a system of locks was evolved comprising grand master keys, master keys, sub-master keys, and individual keys as necessary; as far as possible all movable furniture in the building is of metal, desks, tables, bookcases, files, etc. being of steel, while chairs are of aluminum, in keeping with modern engineering practice; cognizance was taken of the fact that in general electrical testing is done at a center where equipment is available, whereas instruments and equipment are generally assembled at the unit for mechanical testing; instrument rooms are provided by each department adjacent to the laboratory on all three floors; these rooms in both cases are in a vertical tier and provided with dumbwaiter and spiral stairway for the convenience of the attendants; the instrument room on the second floor, in both cases, is backed up by an adequate departmental repair shop.

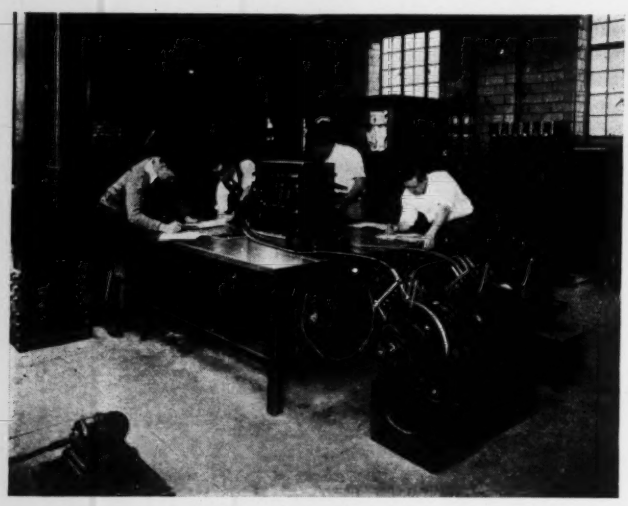

FIG. 3 STUDENTS AT WORK IN ELECTRICAL LABORATORY, SHOWING SPECIAL DETAILS OF TESTING ARRANGEMENTS

FIG. 4 MAIN ELECTRICAL-ENGINEERING LABORATORY, SHOWING MECHANICAL-ENGINEERING LABORATORY AT FAR END

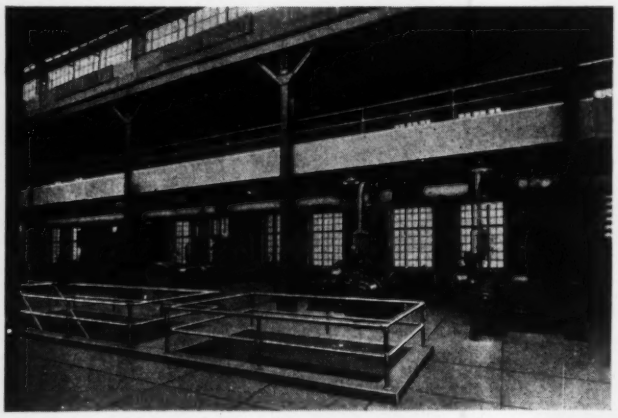

FIG. 5 PART OF MECHANICAL-ENGINEERING LABORATORY

ELECTRICAL FACILITIES

In planning the electrical equipment and wiring of the building, the aim has been to provide all the kinds of electric service that are known to be useful and desirable and to leave room for future extensions or additions. In laying out the wiring, care was taken to provide the maximum of flexibility and to avoid a commitment to fixed layouts which, filling the present need, might not prove desirable in the future.

Power is received from the University sub-station through a four-conductor cable in the form of 4000-volt, 60-cycle, 3-phase alternating current. The switches controlling the supply to the transformers and machines are remote controlled from the operating board and housed, together with the transformers, in fireproof vaults immediately behind the board. The conversion apparatus includes transformers aggregating 560 kva. of capacity, a 150-kva. motor-generator set for supplying direct current, a 50-kva. convertor for the same purpose, a 50-kva. 25-cycle motor-generator set, and a large storage battery with its charging machines. The general lighting and power service is kept separate from the laboratory power supply.

Electric power is supplied to 14 distribution panels by a series of mains. Each of these panels is located at a convenient point in the building and contains circuit breakers and disconnecting switches controlling the supply to special receptacles from which any kind of power may be dispatched to any one of the working stations whose lines terminate on the particular panel. Groups of twelve conductors of ample size provide intercommunication among neighboring panels and each of the panels has one of these groups running to the central or exchange panel located in the main laboratory. By this expedient, a working station in a remote corner of the building may be quickly connected with a similar station elsewhere. Connections so made may be retained for some time as semi-permanent wiring.

The main laboratory floor is provided with permanent working stations including a seven-wire panel with fused switches, receptacles, and binding posts fed by way of a duct beneath the

concrete floor, an electrically welded steel-frame wood-top table, and an equipment of water loading rheostats of novel construction. The machinery is practically all direct connected and mounted on rigid steel bases. Each unit is placed on the floor beside a table without any form of fastening. This permits rearrangement of the apparatus as frequently as may be found desirable. A large number of outlet panels similar to the one referred to are located along the walls of the various smaller laboratories and research rooms and on the demonstration tables of the lecture rooms. One hundred and forty-four of these working outlets are provided throughout the building.

The experimental wiring on the electrical-engineering side of the building is run horizontally through steel ducts of special construction. These ducts contain 6 or 12 steel shelves and provide space for 72 or 144 wires of large size; all of them may be opened throughout their length so that changes may be easily made or additional wiring installed in the spare space available. The wires are run vertically through a wire shaft where they are supported by ebony asbestos slabs provided with drilled holes and wedges.

Sixty per cent of the floor space of the building on the electrical-engineering side is devoted to laboratory or other experimental work, 30 per cent to instruction, etc., and 10 per cent contributes to the convenience and comfort of students.

MECHANICAL-ENGINEERING FACILITIES

In planning mechanical-laboratory facilities, special attention was given to the supply of steam, electricity, water, and oil, to the disposal of exhausts, and to the minimization of noises, odor, and vibration.

Steam is available at 250 lb. pressure from the power house, rebuilt in 1928. It is transmitted in a 6-in. line through a tunnel and so looped in the laboratory that saturated or superheated steam at 125 or 250 lb. pressure may be provided when and where desired. Electricity is available from the building supply at alternate columns through the flexible system described above. Water is available from the city mains or from the mountain back of the University. It is held in either of two reservoirs of 25,000 gal. capacity under the basement floor, from which it is circulated completely around the testing floor to be returned through weighing tanks or flume or both to the other pit or to waste as desired. Fuel oil for internal-combustion engines is supplied by pumps from either of two tanks placed below ground just outside of the building. Lubricating oil is carried in metal containers equipped with pumps. Exhaust steam may go to condensers, to heating system, or to atmosphere. Internal-combustion-engine exhaust is removed by an exhaust fan discharging through a 30-in. stack built into one of the masonry towers of the building. Noise and odor are minimized by the provision of corridor doors to the main building, and by the complete isolation of the internal-combustion laboratory. Vibration is guarded against by floors designed to carry 400 lb. per sq. ft. and by isolation of the larger internal-combustion-engine foundations from all other parts of the building.

Disposal of space, as on the electrical side, provides 60 per cent for laboratory and research activities, 30 per cent for formal instruction and office, and 10 per cent for student facilities.

Prior to the dedication of the building, the first Packard car will be driven overland from Detroit under its own power and placed in its final resting place in a glass case which will occupy the central space of the main lobby of the building, there to remain as a perpetual testimonial to its designer, and as an inspiration to future students who elect to follow electrical or mechanical engineering at Lehigh.

Motorship "Lafayette"

THIS is the second to the largest motorship in the world and is only exceeded in size by the Italian motor liner *Augustus*. It will be operated on the North Atlantic route as a cabin-class ship with the *Rochambeau* and *DeGrasse*. The keel was laid in May, 1928, the ship was launched a year later, and within a few days of a year after the launching, it entered the service.

There are four main power units in the *Lafayette* arranged for quadruple-screw propulsion. The engines are of six-cylinder, two-cycle, double-acting, air-injection, M.A.N. design, each with a cylinder bore of 600 mm. and stroke of 900 mm. (23.62 in. by 35.43 in.) rated at 4000 b.hp. at their normal operating speed of 145 r.p.m. and 4500 b.hp. at maximum speed, which is 150 r.p.m. At full power the designed speed of the *Lafayette* is 18.25 knots while the service speed is 17.5 knots. At the power and speed stated it appears that she will consume about 240 lb. of fuel per mile for all purposes. It is apparent that the combination of quadruple screws, double-acting two-cycle machinery, and relatively high propeller speed has resulted in a machinery installation requiring less space than earlier Diesel installations.

Although the engines have standard cylinder dimensions and are of late M.A.N. design, they are of the air-injection type, each arranged to drive its own air compressor located in the center. Scavenging air is supplied by three independent blowers operated at 2400–3000 r.p.m. by electric motors installed in a separate compartment which encloses the blowers as well as the motors. Normally two blower units supply all the air required. The blower compartment is in the after end of the main engine room, and air is drawn from the deck through a large trunk insulated to deaden the sound, the compartment itself being well insulated.

There are five auxiliary engines all told, of which three are six-cylinder units of 1050 b.hp., direct coupled to 700-kw. generators, while two smaller engines develop 750 b.hp. each at 250 r.p.m. and are direct coupled to 500-kw. generators. All of the auxiliary units are of four-cycle airless-injection M.A.N. design. The larger engines were built in Germany, while the smaller ones are of French manufacture.

One of the interesting features of the machinery installation is the constant-current system for driving the deck machinery. In principle this system employs constant current instead of constant voltage, thus eliminating fuses and making resistance unnecessary and overloading impossible. The load on the winch fall can be held stationary in mid-air without using the brake, and as the load is lowered, a regenerative effect is obtained by the winch motor delivering current back into the line.

On trials the *Lafayette* achieved a maximum speed of 18.3 knots with the engines turning at 154 r.p.m. The service speed of the vessel is approximately 17.5 knots and the total output required from the four engines is then about 16,200 i.hp. It is arranged to run the two inner main engines at 148 r.p.m. and the wing units at 150 or 151 r.p.m. to avoid synchronizing and the corresponding risk of vibration. The original article in *The British Motorship* gives data on the main-engine conditions at sea and the blast-air pressures for different speeds.—A combined abstract of an article in *Motorship*, vol. 15, no. 6, June, 1930, pp. 364–371 and 391, illustrated, and in *The British Motorship*, vol. 11, no. 123, pp. 96–99, and remark on p. 84.

The Aerodynamics of Leonardo da Vinci

By R. GIACOMELLI,[1] ROME, ITALY

SEVERAL writers on aerodynamics precede their dissertations with a short historical introduction in which, after mention of Aristotle for his ideas on the motion of bodies through the air, and before reaching Newton, whose work furnishes the basis for the science, the name of Leonardo da Vinci is recorded as being the first to attribute the lift and flight of birds to the resistance of the air, and to recognize in that resistance the possibility of solving the problem of flying also for human kind.

Interesting, however, as were Leonardo's observations on flight it is generally admitted that they can hardly be said to have been founded by him on an aerodynamical basis, which latter has only been made possible by modern science.

In this connection attention may be called to the fact that all that is said of the work of Leonardo da Vinci in aerodynamics is based on general impressions only and not on a true and deep knowledge of that work, for hitherto no one has compiled his ideas on the behavior of the air with respect to bodies moving through it.

To repair this omission the author has collected in a book all of Leonardo's writings on the subject, chronologically arranging and expressing them in the language of today so that they may be read without effort. While it is hoped that this work will appear before long in an English edition, the author takes the opportunity afforded by this meeting to present the conclusions of his work on the contribution of Leonardo to aerodynamics.

Leonardo, born in 1452 in Vinci, as his name indicates, near Florence, died in 1519 in France, the guest of King Francis I. The results of his aerodynamic investigations can be summarized as follows:

1 Lift is the effect of relative velocity between air and wings, this velocity, if sufficiently high, producing almost instantaneously a local condensation of the air struck by the wings which is capable of resisting and supporting them.

2 To give rise to this local condensation of air a layer thereof must be struck by a wing with a velocity greater than that with which the pressure can be transmitted to layers back of it. Under these conditions the air, not being able to yield under the pressure thus rapidly applied, loses its gaseous properties and assumes those of a solid body.

3 Surfaces other than wings, if of suitable form and appropriately disposed as regards the air, are able to exert lift. Thus, besides ornithopters, an aerial screw and a parachute were also designed by Leonardo.

4 The existence of relative velocity being a condition for lift, it is exactly the same where a flapping wing strikes air in repose, or air in motion strikes a motionless wing—the statement of the aerodynamical reciprocity principle!

By means of this principle flapping and soaring flight were identified by Leonardo, and the solution of human flight appeared possible to him, since a man, although too weak to propel it by means of his muscular efforts alone, is able to guide and balance a flying machine if it is propelled by the wind.

5 The wing of a bird, which, when there is wind, is an organ of lift and balance only, becomes in the absence thereof an organ of propulsion as well. Propulsion and lift are accomplished with two different parts of the wing; the base of the wing supports, the tip propels.

6 Leonardo only succeeded in liberating himself from the influence of the ancient philosophy as regards certain presumed actions of air assisting motion after some 20 years of meditation and efforts; while the remaining years of his life were employed in accumulating proofs of the correctness of the ideas which had formed the subject of his previous investigations.

7 Drag, as Leonardo saw it, depended essentially on air condensation resulting from a suitable pressure of velocity. And as condensation of air was, according to him, proportional to the velocity of the body striking it, so also was the resistance of the air, or drag, proportional to the same velocity.

Another assumption made by Leonardo on drag was that it is proportional to the surface of the body in motion. His law therefore consisted in the proportionality of the drag to both surface and velocity.

8 Drag in water consisted only in overcoming the resistance of the fluid to movement of a body through it and not at all in any sort of condensation, as water did not share the condensable properties of air. For a ship, Leonardo recognized the most efficient form to reduce this drag to be that known today as the streamlined one, where the flow closes in smoothly behind it and without discontinuity.

9 While in the case of a body moving through water the density of the fluid, owing to its incondensability, remains through it unaltered, with a body moving through air the density of the fluid varies greatly from one part to the other in the vicinity of the body.

The law of the variation of air density was studied by Leonardo for the cases of falling bodies and of flying birds, in the same way that he had attacked the problem of the invariability of water density in connection with falling bodies and of fishes.

10 The law of the distribution of air density around both falling bodies and flying birds was, according to Leonardo, as follows:

In the case of a falling body air is condensed below it and is forced downward, rarefaction meanwhile taking place at the sides and above the body, the lateral air forming at the same time eddies, and that above closing in above the body—all these air movements, however, being but momentary.

Air condenses ahead of and below a bird in flight and rarefies above and behind it; condensation ahead is more important than that below, and rarefaction behind more important than that above; both condensation and rarefaction vary with the forward velocity of the bird.

Substituting now the terms "high air pressure" and "low air pressure" for "condensed air" and "rarefied air" as used by Leonardo, we shall have a picture of the distribution of air pressures around airfoils similar to that presented by the aerodynamics of today!

[1] Private Docent of the History of Mechanics. Raphael Giacomelli was born in Rome in 1878, and was graduated in mathematics at Rome University, where he was elected Private Docent, or Lecturer, in the History of Mechanics. He entered aeronautics in 1913. From 1913 to 1919 he served in the Aerological Service and during the War he was a Captain in this service. From 1920 to the present time he has been in charge of technical publications of the Air Ministry. From 1920 to 1924 he was Secretary of the Associazione Italiana di Aerotecnica which was founded in 1920 by his efforts. During 1928 and 1929 he was the Italian representative of the Daniel Guggenheim Fund for the Promotion of Aeronautics.

Presented at the Fourth National Meeting of the A.S.M.E. Aeronautic Division, Dayton, Ohio, May 19 to 22, 1930.

Production of Plastic Molded Telephone Parts

A Description of the Hydraulic Presses, Auxiliary Equipment, and Tools Used in the Manufacture of Certain High-Production Plastic Molded Telephone Parts

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THE Western Electric Company now manufactures for Bell System apparatus a large number of different phenol-plastic, shellac, and hard-rubber molded parts, the output of which varies from a few thousand to several million per year. The majority of these molded parts are produced in comparatively small quantities, but certain of them, such as the phenol-plastic molded parts used in the hand-set type of telephone, a new molded subscriber's set housing, and the receiver shell, cap, and mouthpiece used on the older type of desk-stand telephone, are heavy-running parts. The tools and press equipment used in the production of these parts are described in this paper.

The phenol-plastic molded parts for the hand-set type of telephone used by the Bell System constitute the largest class of plastic molded parts now produced for telephone use. The hard-rubber receiver shells and caps and shellac-composition mouthpieces for the desk-stand and wall types of telephones formerly constituted the largest class of plastic molded parts made for telephone apparatus and, with the exception of shellac-composition mouthpieces, are still second in quantity of output. The shellac-composition telephone mouthpiece used for many years is now being replaced by a similar phenol-plastic part and the output of this single part is now several million per year, most of which are used for replacing shellac-composition parts now in service. The hand-set telephone and the hard-rubber receiver shell and cap are too familiar to call for illustrations. The molded subscriber's set housing, which has replaced the older drawn-steel housing, is illustrated in Fig. 1 and will be produced at a rate of more than one million per year. This part weighs about 10 ounces and is a good example of high production of a fairly large plastic-molded part.

Hydraulic-Press Equipment

The hydraulic-press equipment of the plastic-molding plant used for the production of the above-mentioned and other plastic-molded telephone parts contains a number of different classes of hydraulic presses varying in capacity from 15 to 350 tons. In the following classification of the different types of presses used, the parts produced on them are also described.

Inverted Semi-Automatic Presses. A number of presses of this class, varying in capacity from 15 to 125 tons, are used for the production of a large number of different phenol-plastic and shellac molded parts, the requirements of which are moderate. The molds used on these presses are of the so-called "semi-positive" type, channeled for steam and water, and containing generally from 1 to 10 cavities. One of these presses is illustrated in Fig. 2.

Tilting-Head Presses. This class consists of a number of tilting-head presses of conventional design, varying in capacity from 70 to 150 tons, which are used principally for the production of the hand-set telephone handle which is, at present, the most complicated high-production part. One of these presses, equipped with hand-set-handle mold, is shown in Fig. 3.

Gas-Heated Presses. A number of 60-ton multiple-platen gas-heated presses are used for the production of hard-rubber parts molded from hard-rubber dust. The most familiar example of a part produced in this manner is the desk-stand telephone receiver cap, the method of manufacture of which will be described later. For each gas-heated press a duplicate multiple-platen water-cooled cooling press is provided for cooling the molds which are transferred to it by hand. One of these gas-heated presses is shown in Fig. 4.

Duo-Presses. The present equipment of this type of press, which is a special Western Electric design, consists of two 150-ton, eight 250-ton, and four 350-ton capacity presses. This type of press, one of which is shown in Fig. 5, is, as its name implies, two presses in one, having a heating station at the rear of the press, a cooling station at the front, and a table which revolves around a central column for transferring the molds from one station to the other. The heating station consists of an upper stationary steam- or electrically heated platen and a similar lower heated platen which is raised by the main hydraulic ram of the press and lowered by hydraulic pull-backs. When the press is closed at the heating station, the mold is lifted from the revolving table and pressed against the upper heating platen. The mold is thus heated by conduction from the two platens between which it is held. The cooling station is similar to the heating station except that the upper platen is attached to a tilting head which is equipped with jaws for lifting the upper half of the mold. A subpress ram at the cooling station, of somewhat lower capacity than that of the main ram, is used to close and open the molds. The platens at the cooling station are channeled for water cooling. This type of press is now used for the manufacture of all the high-production phenol-plastic parts now used in Bell System apparatus with the exception of the hand-set telephone handle.

The principal advantages of this design of hydraulic press may be briefly stated as follows:

1 High production per unit of floor space and economy in consumption of steam and water.

2 The advantage of the tilting-head construction with higher capacity than is available in other tilting-head-type presses.

3 Low first cost and low maintenance cost of molds, owing to omission of steam and water channels, with resultant reduction in mold deterioration from shrinkage cracks caused by the rapid temperature changes present in direct-heated molds.

Hydraulic Pumps and Accumulators

The molding plant is equipped for three different hydraulic

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pressures, 300, 1000, and 2500 lb. per sq. in. Th 300- and 1000-lb. hydraulic pressures are supplied by pumps and weight-loaded accumulators of conventional design. The 2500-lb. hydraulic

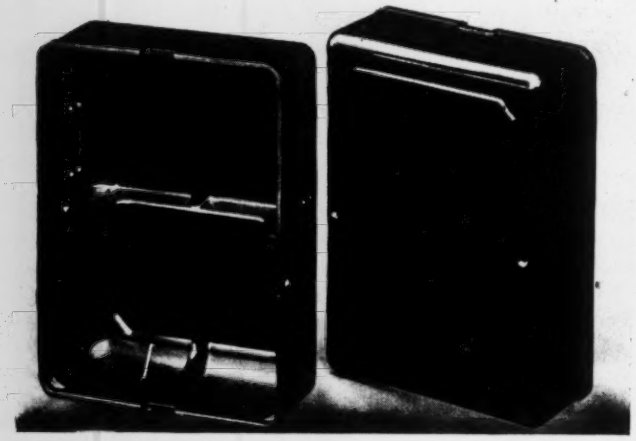


FIG. 1 PHENOL-PLASTIC MOLDED SUBSCRIBER'S SET HOUSING

FIG. 3 TILTING-HEAD HYDRAULIC PRESS WITH TELEPHONE HAND-SET-HANDLE MOLD

pressure is supplied by two 18-g.p.m. triplex pumps and a high-pressure pneumatic-type accumulator. The motor-driven three-cylinder hydraulic pumps force water into a vertical accumulator cylinder containing a floating piston, against the opposite side of which a pressure of 2500 lb. per sq. in. is exerted by the air in the steel air bottles or cylinders.

The operation of this accumulator can be readily described with the aid of the diagrammatic sketch shown in Fig. 6. The space and connecting pipes occupied by high-pressure air are shown unshaded and that occupied by water, shaded. The piston in the accumulator cylinder rises or falls in proportion to the difference in the amount of water drawn from the system and the amount replaced by the pumps. The movement of this piston controls the pumps which supply additional water as required. The pumps run continuously and are equipped with Holveg synchronized controls which, by lifting the suction valves, control the amount of water pumped into the accumulator cylinder and the connecting hydraulic lines.

In starting this equipment the original charge of air is pumped into the air bottles from the compressor, shown in the lower left-hand corner of Fig. 6, until the desired pressure is reached, after which only a small additional amount of air is needed about once a month to replace losses. This equipment has been in

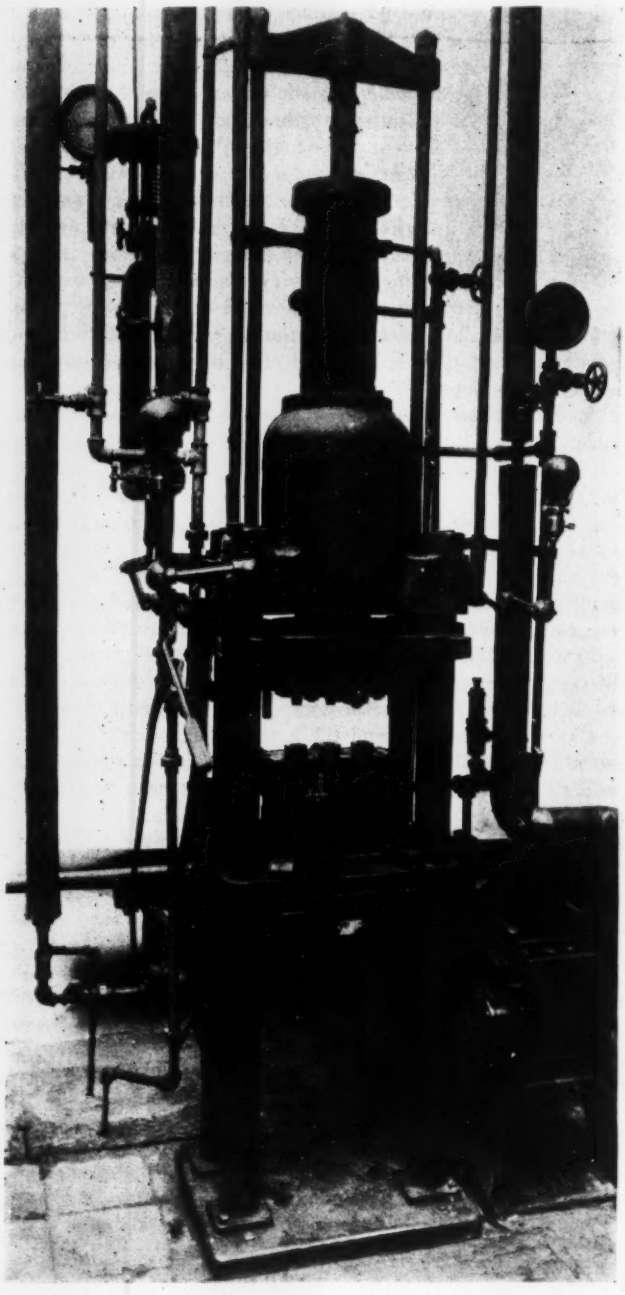


FIG. 2 INVERTED SEMI-AUTOMATIC HYDRAULIC PRESS

use about three years and from the standpoint of moderate first cost, low maintenance costs, and freedom from operating troubles has been quite satisfactory.

MANUFACTURE OF PHENOL-PLASTIC PARTS

The production methods used in the manufacture of certain of the heavy-running plastic molded parts previously mentioned will now be described and the most complicated part, the hand-set telephone handle, will be considered first. This part is irregular in shape and contains seven metal inserts and two circuit wires per part.

The mold details constituting the mold cavities for these parts are made from a 90-point carbon, 1.20-per-cent manganese, low-shrink, oil-hardening tool steel. The principal consecutive operations in the manufacture of the parts of a single cavity of one of these molds are shown in Fig. 7. It will be noted that the upper

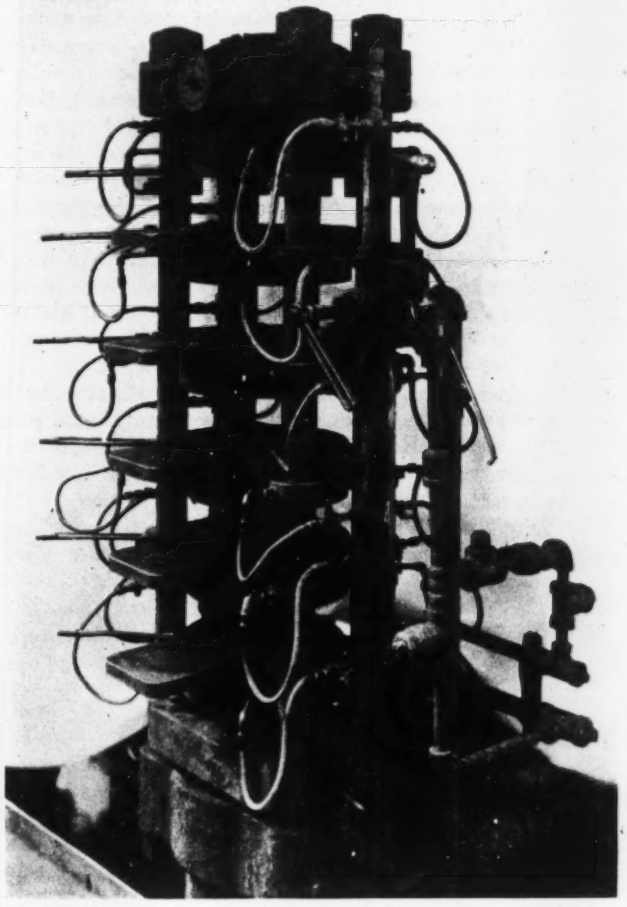


FIG. 4 MULTIPLE-PLATEN GAS-HEATED HYDRAULIC PRESS

and lower halves of this mold part along a flash line around the side of the handle and that the mold cavity itself, with the exception of the round-end cavities at the end of the bottom half, consists of an irregular curved surface somewhat difficult to duplicate readily. The method of machining these cavities is briefly as follows: The first step in preparing for the manufacture of duplicate molds for the production of handles in quantity was the manufacture of two hardened-steel master hobs, one a duplicate of the lower half of a hand-set handle up to the flash line, the other a duplicate of the upper half of the handle. The curved surfaces of these master hobs were developed by shaping the surface to fit metal templates containing the cross-sectional contour of the handle at different positions along its major axis. The master hobs were then hardened and used as master templates for the development of the mold cavities in the production molds. The mold cavities for this part are not made by the so-called "hobbing" process, which would be impracticable with steel of the composition used for these molds, but are machined, principally on Kellar

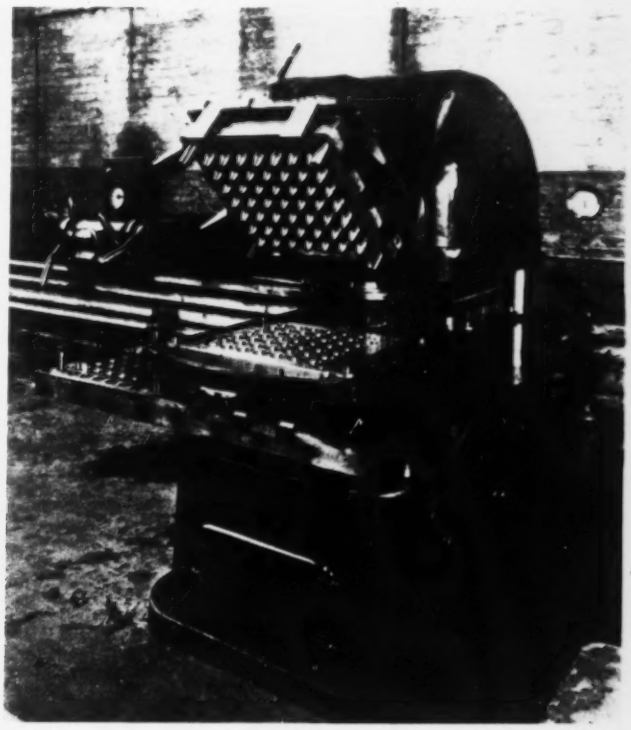


FIG. 5 HYDRAULIC 250-TON DUO-PRESS

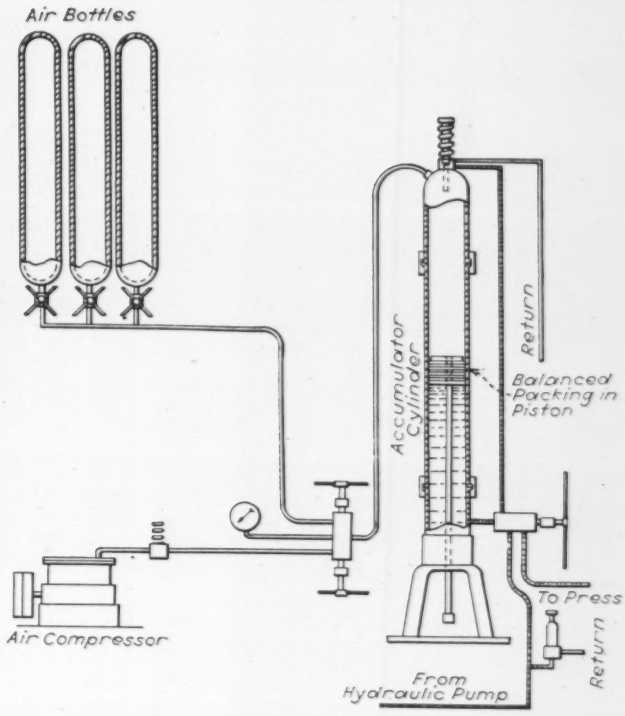


FIG. 6 DIAGRAMMATIC SKETCH OF PNEUMATIC ACCUMULATOR

engraving machines, from master cavities. The mold cavities are rough machined on a Kellar electrically controlled automatic engraving machine, after which they are finish machined to within

about 0.005 in. of their final size on a Kellar mechanical engraving machine. The cavities are then scraped by hand using the master hob, previously mentioned, with Prussian blue to locate the high spots on the surfaces. This process is carried to a point where a fairly well distributed uniform contact is obtained between the surface of the master hob and the mold cavity, after which the cavity surfaces are polished preparatory to hardening. All the machine work, such as drilling of holes and recesses for details is completed, of course, before the polishing and hardening of the mold cavities. These mold details are then hardened by heating to approximately 1450 deg. fahr. in molten sodium cyanide and are quenched by slowly immersing the part, hanging lengthwise, in oil. The oil and cyanide are cleaned from the hardened part by boiling in water, after which the part is pre-

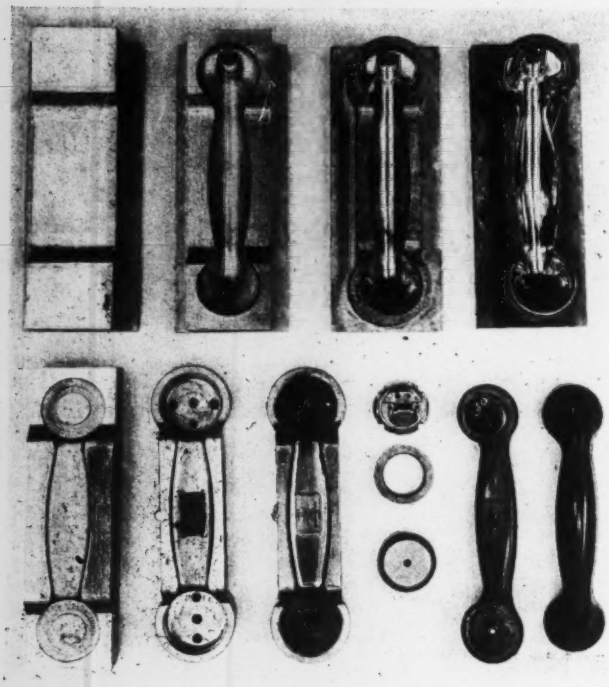


FIG. 7 HAND-SET TELEPHONE-HANDLE MOLD DETAILS IN DIFFERENT STAGES OF MANUFACTURE

heated to a moderate temperature and tempered by immersing it in a molten bath of Houghten's 275-deg. salt maintained at a temperature suitable for producing a final hardness of Rockwell C-58 to 62. The hardened parts are ground all over to final dimensions with the exception of the cavity surfaces which are polished with abrasives of increasing fineness, ending with a final polishing with Triple-X Alundum. Each of the production molds contains eight cavities, and the plungers containing the upper half of the cavities are mounted on a steel plate suitably channeled for heating and cooling. The lower half of the mold consists of a steel block approximately 6 in. thick, suitably channeled for steam and water, containing the cavities into which the details constituting the bottom portion of the mold cavities fit. This type of mold is mounted in a 150-ton tilting-head press and the molding cycle consists of a $6\frac{1}{2}$-min. curing period at a temperature of 340 deg. fahr. and a $2\frac{1}{2}$-min. cooling period.

The metal inserts for the handle are assembled in the smaller removable details which are then placed in the two end cavities of the bottom half of the mold. This bottom-half detail of the mold is then placed in the cavity in the mold chase and a measured amount of phenol-plastic molding powder added.

The press is closed and the part cured as previously described under a pressure of about 2000 lb. per sq. in. After the required curing and cooling, the mold is opened and the bottom detail of the mold, together with the molded handle, removed to the bench for dismantling. The molded part is finished by buffing and polishing operations which remove the fin left at the parting line of the mold.

The six other high-production molded hand-set parts, which are smaller and somewhat simpler to mold than the handle, are molded on duo-presses, as is also the molded subscriber's set housing and the desk-stand telephone-transmitter mouthpiece. The method of molding the transmitter mouthpiece will be described as the process of molding is, in general, representative of the methods used on the other hand-set telephone parts. Fig. 5 shows a duo-press equipped with transmitter mouthpiece molds and in Fig. 8 an operator is seen placing the threaded mold details for molding the threaded neck of the mouthpiece in the bottom half of the mold with a loading fixture. The mold cavities are then charged with equal portions of molding compound and the press is closed. At the end of the curing cycle, which in the case of this part is 4 min., the parts are ejected from the lower half of the mold by raising, with the aid of the subpress ram, the sliding fixture shown at the left side of the press in Fig. 5 which contains a series of ejecting pins which enter holes in the bottom of the mold and raise the threaded mold details carrying the molded parts. These are then removed from the mold with a handling fixture, one of which is shown lying on the bench beside the workman at the left in Fig. 8. The details are unscrewed from the molded parts with the aid of motor-driven fixtures, one of which is shown on the bench in the same picture. The mouthpieces carry molding "flash" around the rim of the large end and also across the small holes in the grid at the threaded neck. This flash at both ends is removed in a single operation with a special fixture. Forty-nine parts per heat are produced and the output per hour per press is therefore about 735 pieces. The annual output of this part is several million, most of which are used to replace the shellac-composition mouthpieces now in service. The phenol-plastic mouthpiece is manufactured at a cost slightly higher than that of a shellac-composition mouthpiece but, owing to its superior physical strength and freedom from breakage in service, its use is an economy to the Bell System.

The molding of the subscriber's set housing illustrated in Fig. 1 has certain features of interest. Duo-presses of 350-ton capacity are used for the production of this part. Fig. 9 illustrates one of these presses and an 8-cavity mold.

It will be noted that this molded part contains, in addition to the two screw holes which are produced in the molded box by pins set into the mold, a series of slots in both sides and in one end of the box which are molded by details which are automatically withdrawn on opening the press. The molded boxes are raised slightly to permit easy withdrawal from the mold by means of pins in the ejecting fixture which is elevated against the bottom of the mold by the subpress ram. These ejecting pins lift the box by pushing upward on the pins which form the screw hole in the box. The production of these boxes by molding is a good example of the advantages of plastic molded parts where good finish and mechanical properties are desired in the finished part with a minimum number of operations. The box is practically finished when it is taken from the mold and requires only the removal of the flash from the edges by means of a surface grinder, and from the slots by a punching operation. The older design of steel housing required carefully developed tools to enable the box to be drawn at a single operation and a special grade of deep drawing sheet steel. After forming, the steel box was washed to remove grease, annealed to remove drawing strains, and trimmed. The openings were then blanked out, and the box buffed and japanned. It is not surprising, in view of the reduc-

tion in number of operations, that the molded housing is preferable from a manufacturing and cost standpoint. In addition to the lower manufacturing cost of the molded housing, the permanence of its finish as compared to a japanned steel housing results in lower maintenance costs in service.

Another interesting molded part which, for its size, probably holds the record for number of inserts, is the test strip shown in Fig. 10. This part contains 200 brass pins uniformly spaced parallel to each other. It is 7¾ in. long by 1 in. wide and is molded from four preforms composed of a very soft grade of phenol-plastic compound. The molding pressure is applied parallel to the pins by a plunger which contains a hole for each pin to recede into as the mold closes.

MANUFACTURE OF HARD-RUBBER MOLDED PARTS

The manufacturing methods used on high-production hard-rubber parts are of interest, and good examples are the receiver shell and cap used on the desk-stand telephone. The shell is molded from rubber compound and the cap from hard-rubber dust which is made from scrap hard rubber ground to about 50 mesh. The molding of the cap represents a transition in plastic-molding practice between phenol-plastic molding and rubber-compound molding and will, therefore, be described first. These caps are molded with a square-edged rim, in multiple-cavity hand molds such as are shown in Fig. 11. The body of the mold is steel and has a cavity lined with brass. The upper and lower halves of the cavity are formed by two cylindrical details made from a "duralumin" type aluminum alloy which has proved satisfactorily resistant to the corrosive action of the sulphur in the rubber dust. A measured charge of dust is placed in each cavity in the mold, and the mold is then closed in a gas-heated press of the type shown in Fig. 4. The part is cured for 20 min. at a temperature of about 400 deg. fahr. under a pressure of about 2000 lb. per sq. in., after which the mold is transferred by hand to a

FIG. 8 MOLDING PHENOL-PLASTIC PARTS ON HYDRAULIC DUO-PRESSES

cooling press which is a duplicate in construction of the heating press. When the mold is cool the parts are ejected and the threaded detail is unscrewed by means of a motor-driven fixture. The cap is machined to its final shape on a semi-automatic machine shown in Fig. 12, which consists of a horizontal circular table carrying a series of threaded revolving heads on which the caps are screwed by the operator as the table turns. The contour of the rim of the cap is machined, the center hole drilled, and the finished cap ejected automatically. The output of this machine is about 2000 parts per hour. Hard-rubber dust can be molded only into comparatively simple shapes as it does not become sufficiently plastic during molding to fill parts of intricate shape; nor does it undergo any reaction during molding such as vulcanization or the polymerization which plays so important a part in the molding of phenol plastics. Hard-rubber dust produces a molded part merely by being fused together under heat and pressure.

The desk-stand telephone receiver shell is a good example of rubber-compound molding in which a plastic rubber compound is molded to shape and hardened by vulcanizing. The unvulcanized rubber compound is prepared in sheets about ¼ in. thick from which are blanked the irregularly shaped pieces shown in Fig. 13, two of which are used for each receiver shell. As the vulcanizing time in the production of hard-rubber parts such as this one is a matter of hours, the use of molding presses is impractical, as the relatively small capacity of the press and the long curing time would necessitate an excessive investment in equipment. These parts are, therefore, molded in aluminum-

FIG. 9 350-TON DUO-PRESS

alloy molds, a number of which are stacked on steel trucks and blocked with steel wedges to maintain the pressure on them. These trucks are then placed in large steam vulcanizers and the parts are vulcanized under steam pressure at a temperature of about 300 deg. fahr. for half an hour. A loaded truck and one of the vulcanizers are shown in Fig. 14. At the end of the half-hour period the shells are sufficiently cured to permit removal from the molds. These parts require, however, additional curing to complete the vulcanization and to produce the desired physical strength and resilience in the finished part. To obtain this additional curing with economy in steam and vulcanizer space, the shells are left on the core, around which they have been molded, and are returned to the vulcanizer where they are given an additional five-hour cure at the same temperature as before.

The finished part must be machined over its entire exterior surface and this is done on automatic lathes in which the tool, guided by cams, starts at the cored hole in the end of the shell and turns the entire outer surface to the desired contour. The shells are then buffed and polished and the threads and diaphragm seat are machined in the flared rim.

MANUFACTURE OF SHELLAC MOLDED PARTS

Plastic molding compositions containing shellac as the principal resinous binding agent have been in use for many years, and

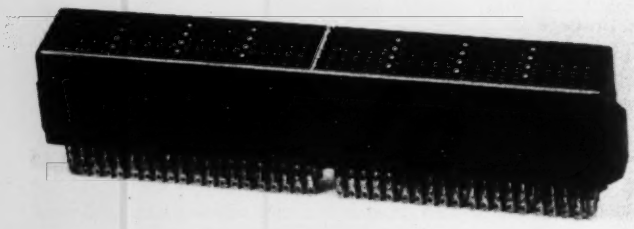


FIG. 10 MOLDED TEST STRIP

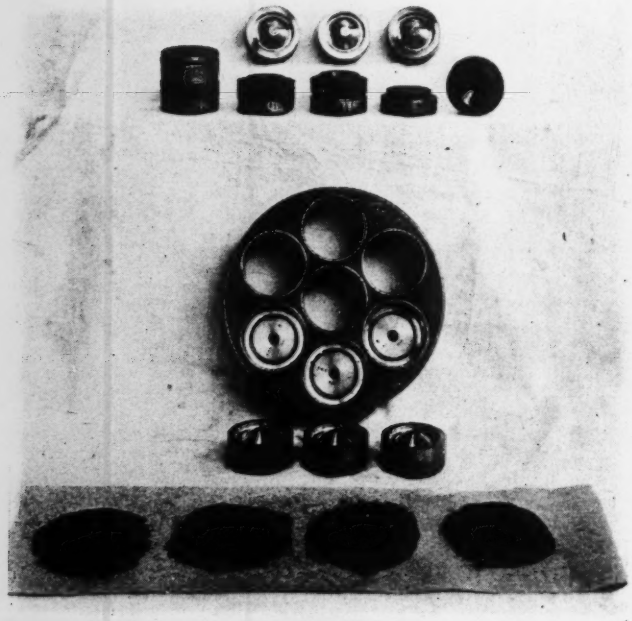


FIG. 11 MOLD AND MOLD DETAILS FOR MOLDING RECEIVER CAPS FROM HARD-RUBBER DUST

FIG. 12 MACHINING HARD-RUBBER RECEIVER CAPS

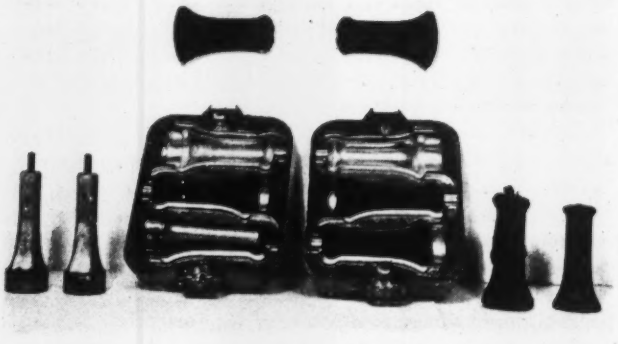


FIG. 13 RECEIVER-SHELL MOLDS, CORES, AND UNVULCANIZED-RUBBER BLANKS

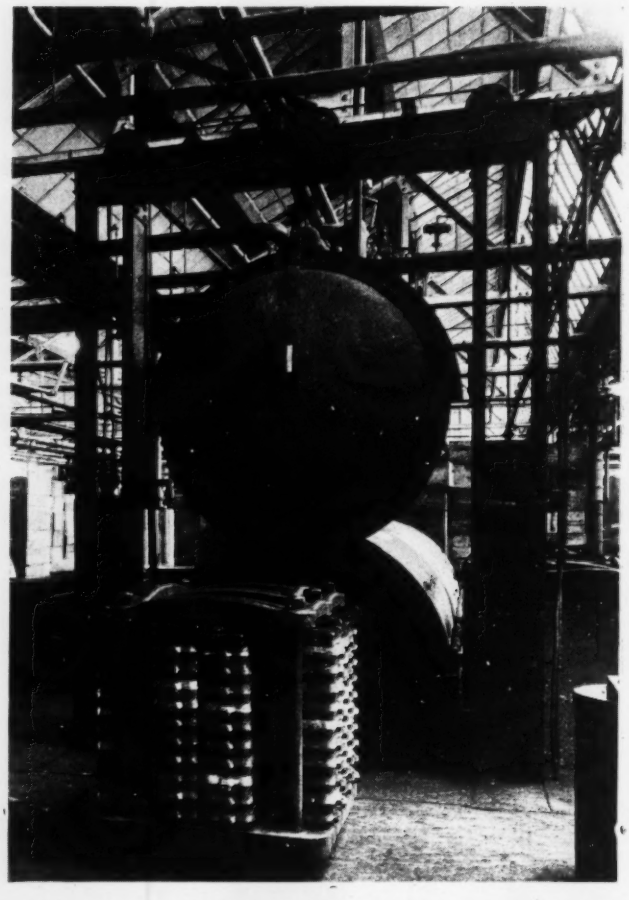


FIG. 14 RECEIVER SHELLS IN MOLDS READY FOR FIRST VULCANIZING

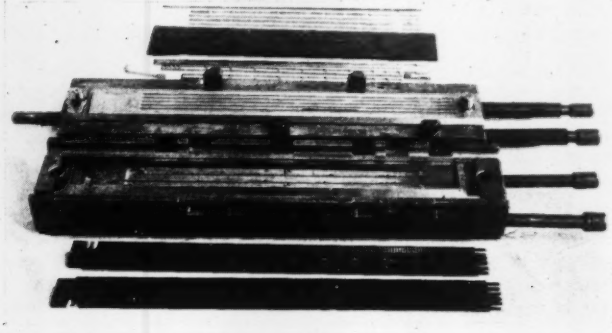


FIG. 15 FLASH-TYPE MOLD AND SHELLAC-COMPOSITION PANEL DIAL-SYSTEM COMMUTATORS

despite considerable experimental work with other resins as shellac substitutes, shellac is still widely used in the better grade of thermo-plastic molding compositions. The shellac compositions used in Bell System parts contain 20 to 50 per cent of shellac with the remainder principally 100-mesh ground mica or wood flour, together with small amounts of other resins, waxes, and coloring materials.

Shellac compositions of the shellac-mica type are used where resistance to mechanical wear, together with good electrical surface resistivity and mechanical strength, are required. The molding cycle using shellac composition is much shorter than in the molding of phenol plastic, and shellac-composition parts are, therefore, frequently lower in cost than phenol-plastic parts, as the shellac compound can be produced at a price comparable with current prices of phenol-plastic compounds and the output per press is considerably higher.

The principal shellac-composition part now used by the Bell System is known as a panel dial-system commutator, one type of which is shown with the flash type mold used in its production, in Fig. 15. This part is a molded bar containing a number of brass contact strips and because of the number and location of these strips, the production of this part is interesting from a manufacturing standpoint. The compound is softened on a steam plate and laid into the bottom half of the mold in a plastic strip. The brass strips, which have previously been laid into their respective grooves in the mold, are held in place in the upper half of the mold by two long pins inserted in holes in the lugs shown. The two halves of the mold are laid together, the holding pins are withdrawn, and the mold is placed between the platens of a press and closed. This part is finished by grinding and polishing the surface until the molded surface and the brass inserts are uniformly smooth.

PROPERTIES OF PLASTIC MOLDING COMPOUNDS

Plastic molding compounds of the three classes described, phenol plastic, shellac composition, and hard rubber, are used for the manufacture of the parts described for various reasons which involve the design of the part and its use.

Phenol plastic is used where hardness, resistance to abrasion in handling, good electrical characteristics, good finish, high physical strength, and permanence are desired. A major reason for its use in quantity production of irregularly shaped parts, such as the hand-set handle containing numerous accurately located inserts, is the comparatively low cost at which parts of this kind can be produced. A few moments' consideration of other possible materials and methods of manufacture of such a part as the hand-set telephone handle will show that the manufacture of such a part by any other process would be considerably more difficult. The same reasons justify, in varying degrees, the use of phenol plastic for numerous other parts.

Shellac compositions are used where the requirements for appearance, resistance to softening at elevated temperatures, resistance to corrosion and discoloration in handling are less severe. They are, in general, lower in cost than phenol-plastic parts and where the electrical and mechanical properties required are such as to permit their use, they are quite satisfactory. For certain parts such as the commutator, already described, a shellac-mica compound is superior in resistance to mechanical wear than other plastics, with the possible exception of certain grades of hard rubber.

Hard-rubber parts are used where good mechanical strength, especially in resistance to impact, is desired. They are not entirely satisfactory where high electrical surface resistivity is important as they deteriorate in this respect in the presence of sunlight and moisture. Surface discoloration on aging is also an objection to the use of hard rubber where appearance is important and the cold flow of hard-rubber parts, if subjected to permanent loads, is also objectionable under certain conditions.

Of the three types of plastic compounds discussed, the predominant plastic of the future as regards quantity consumed will probably be the phenol-plastic type, as it clearly possesses more of the properties desired in a plastic compound for general use than any other single compound now available. At current prices of phenol plastic and with modern molding methods, parts molded from these compounds can be produced at costs which make them active competitors of stamped and cast metal parts, and the future will, no doubt, see an even greater use of this valuable and adaptable product than now exists.

Central-Station Smoke

THE *Aerologist* for July prints an account of litigation in England where a farmer appeared as the plaintiff against a central power station, claiming damage because of the sulphur-laden fumes emitted. It was shown that nearly 11 tons of sulphur were discharged in some form from the less than 600 tons of coal consumed daily. These fumes when blown along the ground ruined the vegetation and crops in the neighborhood. In defense, the corporation pled that the power station in question was of the kind authorized by Parliament for such a place and as the nuisance could not be avoided there could be no liability.

The justice in the first court sustained the corporation, but the court of appeal, by a majority decision, awarded damages to the plaintiff, with costs in both courts, and the central station was instructed to adopt such measures as are prescribed to stop or mitigate the nuisance, with liberty to appeal after a year for suspension or variation of the injunction.

This case and its decisions may be far-reaching in importance. The power station of this defendant is said to be one of the most efficient, and large sums had been spent to avoid just such a contingency. According to this precedent a steam plant anywhere might be held liable for nuisance or damage caused from both visible and invisible smoke.

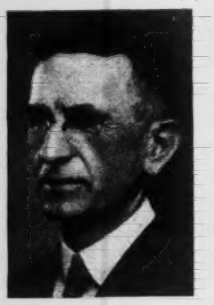
Unquestionably here lies a difficult task for the chemist and engineer. Communities are certain to insist on the power plants of industries emitting only the cleanest gases from their stacks, even though individual householders in the aggregate contribute more to air pollution than all industry combined. Fly ash, sulphur compounds, fumes, and dust—all must ultimately be eliminated. Shall we find economic ways of doing this for each power plant, or shall we gasify our coal or otherwise produce power in great central units where efficient measures can be applied more easily?

Closely related is the present case of damage from smelter fumes charged against the great plant at Trail, B. C. The question of extensive damage to forests is involved for the first time. The situation is further complicated by the international boundary, since the laws of the State of Washington forbid land ownership by aliens. This introduces an additional complication, preventing the practice of buying extensive areas to avoid damage suits. Chemists are among the scientists who are working on this case, the settlement of which is sure to have an important bearing in all cases involving international nuisance and alleged damage.—*Industrial and Engineering Chemistry*, September, 1930, p. 925.

Training Men for the Wood-Using Industries

The Need for Technically Trained Men as Executives, Technicians, and Investigators in These Industries and the Course of Study Provided at the University of Michigan

By SAMUEL T. DANA,[1] ANN ARBOR, MICH.



RECOGNITION of the need of technically trained men in the wood-using industries is a comparatively recent development. While experts have been called on to play their part in solving the many problems involved in the most effective use of iron, steel, cement, rubber, and other raw materials, it has been complacently assumed that no special knowledge was needed to use wood satisfactorily. In no other major industry has the sentiment so generally prevailed that "what was good enough for my grandfather is good enough for me."

This attitude may be due in part to the deeply rooted but no longer tenable belief that wood is such an essential part of our industrial life that it will continue to sell itself no matter how poorly it may be handled; in part to failure of our educational institutions to turn out men properly prepared for service in this field; and in part to other reasons. Whatever the cause, it is evident that the wood-using industries today are coming to realize that technical knowledge is not only a desirable but an essential factor in enabling them to hold their own in the keen competition of the modern industrial world. It is safe to say that the future prosperity of these industries depends in a large measure upon the extent to which this growing recognition of an important need is translated into practice through the employment of qualified men.

Technical men in the wood-using industries can perhaps be divided roughly into three main groups: the executive, the technician, and the investigator. Each of these, to discharge his special function effectively, must have a scientific background which has so far been conspicuous chiefly by its absence.

The Task of the Investigator

The investigator's main task is obviously to find out more about the characteristics of wood and the relation of these characteristics to its industrial utilization. Wood, in spite of the complexity resulting from the fact that it is an organic product, has probably had less really careful study of its structure, composition, and properties than any other of the important raw materials of industry. There is not a single one of our 100 odd native species of commercial importance, all of the properties of which have been investigated, to say nothing of the large number of foreign species, particularly from the tropics, which are potential substitutes. In these days how can an industry expect to prosper permanently which, broadly speaking, knows practically nothing of the raw material upon which it is dependent? How can new woods be used, new processes developed, and new products manufactured without the knowledge obtainable only through thorough-going study by trained men?

The need for information of this sort is now pretty generally recognized, but there is more doubt as to whether the wood-using industries recognize their own responsibility in the matter. The general attitude is rather "Let George do it," George, in this case, being primarily the Forest Products Laboratory of the United States Forest Service with secondary consideration to such educational institutions as may be interested in the problem. The Forest Products Laboratory has done excellent work, which by the way has not been fully applied by the wood-using industries, and its activities, as well as those of the educational institutions, should doubtless be expanded, but it is unreasonable to expect public agencies to carry the entire burden of solving all of the wood-using industries' problems. If these industries are to maintain their place among the industries of first importance, they themselves must participate in the endless search to find out all there is to be known concerning wood and its uses. With millions of dollars being spent for research each year by the steel, chemical, photographic, and telephone industries, to name only a few, it is inevitable that the wood-using industries must undertake similar research on their own initiative and under their own direction. Whether the work is done by individual companies, through association activity, or by the establishment by the industries of some special research institute, it is clear that the work must be done by men with the best possible training.

The Technician's Function

The technician's task in industry is primarily that of applying in actual practice the results obtained by the investigator. So far this gap has been a difficult one to bridge, and relatively insignificant as our knowledge of wood still is, far more is known than is put into practice. The Forest Products Laboratory, for example, estimates that at least two-ninths of the present waste in the wood-using industries could be avoided if the knowledge of better practices which has been developed there and elsewhere were actually applied.

Various factors, of course, tend to delay the prompt use of laboratory results for commercial practice. Some of these may be beyond the control of the individual concern. Perhaps the most common and easily remediable difficulty, however, lies in the fact that special technical training is now required before the information already available can be utilized to anything like the fullest advantage.

The efficient operation of any wood-using industry today, whether its activities involve wood turning, wood preservation, kiln drying, steam bending, plywood production, or any other process, is by no means a purely routine affair to be reduced to rule of thumb and turned over to an ordinary foreman. Technical knowledge of wood and its uses is an essential attribute of an

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efficient manager of any up-to-date wood-using plant, and is still more essential if the plant's practices are to be kept in accord with the latest discoveries in the field of wood technology. The task of scrutinizing practice in any wood-using industry or individual concern, with a view to applying those research findings by which economies may be effected or revenue increased, is emphatically one which demands the services of men with sound training in such matters as the structure, physics, mechanics, chemistry, and pathology of woods; men who can not only direct the activities of the manufacturing plant but serve as a connecting link between it and research organizations.

THE EXECUTIVE'S RESPONSIBILITY

Finally, the executive in a wood-using industry today is hardly less in need of technical training than the technician and the investigator. While business ability is, of course, a first requisite, this must be supplemented by first-hand knowledge of the raw material and the processes by which it is manufactured if the executive is to control effectively the activities of his lieutenants. Lawyers, bankers, and plain business men have obviously made good as major executives in every industry, but there is little doubt that their task would have been easier, and their success still more outstanding, if their other abilities had been

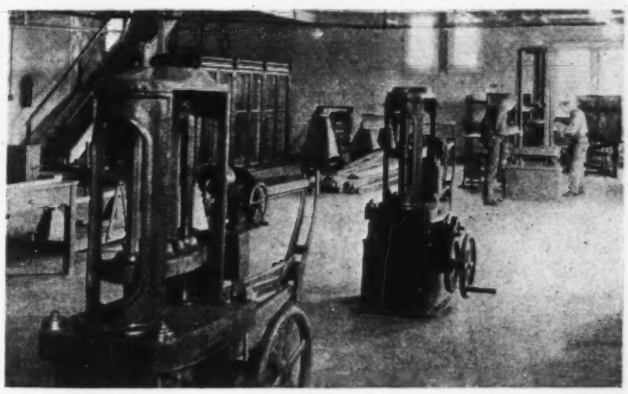

FIG. 1 TIMBER-TESTING LABORATORY, SCHOOL OF FORESTRY AND CONSERVATION, UNIVERSITY OF MICHIGAN

supplemented by a technical knowledge of the product with which they were dealing.

It has been the experience of the engineering profession that there is an increasing tendency for men starting out as technicians to work into executive positions, and the education of engineers to enable them to do this is now a recognized function of the engineering schools. There is no reason why the same thing should not be true of the forestry profession and the forestry schools. Indeed there is every reason to believe that foresters, with their varied knowledge of wood and its utilization, can serve the wood-using industries not only as technicians and investigators but perhaps even more effectively in positions of executive responsibility where their technical knowledge can be called upon to advantage in the determination of broad business policies.

THE FORESTER'S INTEREST IN WOOD UTILIZATION

The forest schools, like the wood-using industries, now recognize more clearly than ever before the importance of applying technical knowledge in the utilization of forest products. Moreover, they recognize much more clearly than ever before their own responsibility in the education of men with adequate technical and other training not only to discover and apply new facts and processes, but to take the leadership as business executives. This represents a change in emphasis as compared with the situation only a few years ago which is perhaps not yet fully appreciated by the wood-using industries.

Hitherto foresters have undoubtedly had the reputation of being far more interested in forest production than in wood utilization. Timber growing has to a large extent absorbed the attention of men who have gone out from the forest schools. They have been interested in protecting the forests from fire, insects, and diseases, in cutting mature stands so as to get a new crop of desirable species, in improving the quality and increasing the quantity of material produced by second-growth stands, and in planning cutting operations so as to maintain a continuous

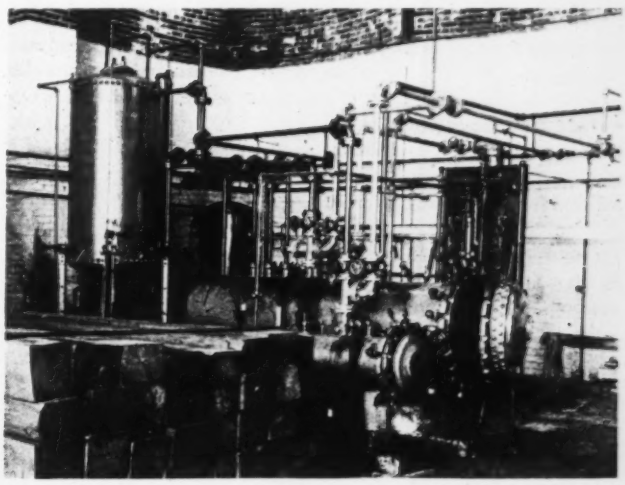

FIG. 2 WOOD-PRESERVATION PLANT, SCHOOL OF FORESTRY AND CONSERVATION, UNIVERSITY OF MICHIGAN

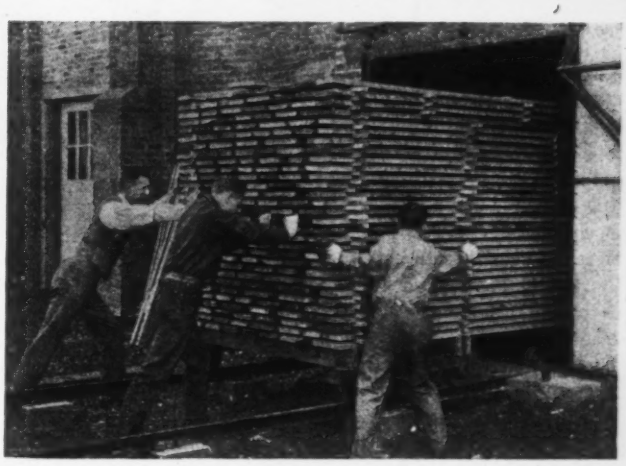

FIG. 3 LOAD OF LUMBER ENTERING SEMI-COMMERCIAL DRY KILN, SCHOOL OF FORESTRY AND CONSERVATION, UNIVERSITY OF MICHIGAN

yield. More recently they have been paying increased attention to the harvesting of the timber crop. Logging engineering with its many varied and difficult problems has been coming more and more to the front. The general layout of a logging operation, including camp location and road construction, the relative efficiency of different methods of logging, the cost of getting out and the comparative value of trees of different sizes, are examples of the sort of questions to which definite answers are being sought. In both of these fields there is no question as to the importance of the work.

Now, however, foresters as well as wood users are beginning to realize that the efficient utilization of forest products by the

wood-using industries constitutes another field which is equally important and in which expert knowledge is equally necessary. The marketing and manufacture of forest products are as much the concern of the forester as is their production. Forest schools must, therefore, turn out wood technologists who can function as investigators, technicians, and executives in the wood-using industries in the same way that silviculturists function in similar capacities in timber growing.

EDUCATION OF THE WOOD TECHNOLOGIST

They are doing this by modifying the orthodox forestry curriculum, which was a pretty rigid affair, so as to make it possible for the student to do more work in the field of his special interest. In effect, forestry schools are recognizing that the student's training should vary according to the particular branch of the profession which he expects to enter after graduation. Obviously the same program of studies will not prepare a man equally well for work in silviculture, forest pathology, forest entomology, logging engineering, and wood technology, just as the same course of study will not prepare a man equally well to be a civil, mechanical, electrical, or marine engineer. Both in forestry and in engineering there are certain fundamental subjects which everyone should take, but beyond this there should be opportunity to elect courses which will best fit him for his chosen work.

Specific illustrations as to how this works out in practice may be cited from the School of Forestry and Conservation at the University of Michigan, not because it is unique in this respect, but because I am most familiar with its program. Every student before entering the school is required to obtain the necessary background for his professional work through two years of college preparation in such fundamental subjects as English, botany, zoology, chemistry, physics, mathematics, and surveying. After entering the school he learns the underlying principles of forest protection, forest production, forest utilization, forest economics, and wood technology. Beyond these he emphasizes, through elective courses, his field of special interest. Thus, those planning to go into the wood-using industries will naturally take additional work in chemistry and physics, in the structure and properties of woods, in the relation of these to wood uses, and in specific processes such as wood turning, wood preservation, kiln drying, and pulp and paper making.

Those desiring to go into research are encouraged to take advanced work leading to the degree of doctor of philosophy, with emphasis on fundamental principles and on the development of the investigative point of view and research technique. The time is practically here when investigators in chemistry, for example, can hardly expect to go far without preliminary training equivalent to a doctor's degree, and it is believed that this time is rapidly approaching in forestry and wood technology.

With the technician and the executive, so long a period of apprenticeship is hardly necessary, although five or six years of work leading to the master's degree is regarded as essential for really adequate preparation. With the prospective technician considerable emphasis is naturally laid on giving him a sufficient acquaintance with wood and its properties to enable him to interpret and apply the results of research, together with a sufficient grasp of existing practices, processes, and methods of wood utilization to make him thoroughly "practical." With the prospective executive, stress is laid upon a thorough understanding of the principles of economics and business administration in addition to his technical training in wood technology. In general his training is comparable to that of the prospective technician except that it may well go further in the latter fields.

A novel and important feature of the work at the University of Michigan is the development of a combined program in forestry and business administration. This is intended to meet the needs of those who desire to devote themselves primarily to the business rather than to the strictly technical aspects of timberland management and of forest and wood utilization. For those looking forward to the wood-using industries it combines training in the fundamentals of forestry with advanced work in wood technology and with strong emphasis on economics, accounting, and business administration. The full program leads, in six years, to the two degrees of Bachelor of Science in Forestry and Master of Business Administration. The courses in business administration include such subjects as the principles of organization and production, principles of personnel, marketing principles, financial principles, managerial statistics, business policy, business law, and business forecasting. Those not desiring to go so deeply into business administration can still obtain several courses in that field in the five years leading to the degree of Master of Science in Forestry.

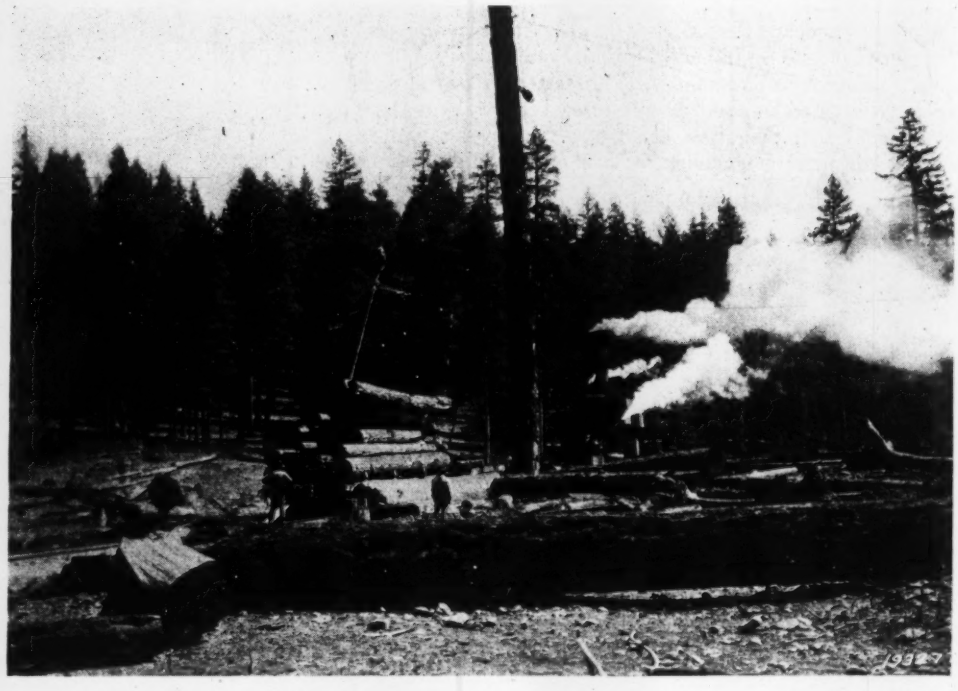

FIG. 4 LOGGING UNDER APPROVED METHODS ON A WESTERN NATIONAL FOREST
(Courtesy U. S. Forest Service.)

It will be noted that this program assumes that the technical man in the wood-using industries, irrespective of his particular line of work, should know something of the characteristics, dis-

tribution, and management of important trees as well as of their wood. This familiarity with the forest is practically indispensable for the well-trained technologist, not only because the character of the wood itself is greatly influenced by the conditions under which it has been grown, the size at which it has been cut, and other factors in the field of forest production and utilization, but because it supplies a background for a more thorough understanding of the raw material with which he is dealing, including such important matters as source, adequacy, and permanence of supply. Moreover, the chances appear to be good that if the wood-using industries desire to remain in business they will have to take definite steps to make certain that adequate supplies are being produced for them by others, preferably within easy distance of the mill, or to go into the timber-growing business themselves. It seems more than probable that the tendency for the same industrial unit to produce, manufacture, and market its product which has been so pronounced in the steel industry will become more and more evident in the forest and wood-using industries. If so, this means that the wood-using industries themselves will have a direct personal interest in forest production in order to assure themselves of a permanent, adequate, and satisfactory supply of raw material. In any event it seems certain that knowledge of the forest-growing end of the business will be an asset which the wood technologist cannot well do without, no matter how complete his knowledge of the strictly technical aspects of wood technology.

All of these facts contribute to make the education of the forester, whether he becomes eventually a silviculturist, a wood technologist, or a general practitioner, a pretty liberal process. Forestry is so broad a field that the acquisition of technical competence in any one of its branches necessarily involves a truly broad preparation in a wide variety of subjects. It is a significant but perhaps not surprising fact that foresters who for one reason or another have not desired to continue in the profession have found little difficulty in making good in an extraordinary variety of other occupations.

In stressing the importance of an adequate technical training for investigators, technicians, and executives in the wood-using industries, the author does not, of course, intend to minimize the importance of practical experience. No one questions the ability of the exceptional man to rise to the top in any line of work without a college training. Education is merely a short cut to acquiring the information achieved by our forbears and contemporaries only by years of study and experience, but it is a short cut of which it is usually necessary for the average man to take advantage if he desires to go far. With respect to the training of wood technologists, we are still in the process of developing the best short cut to turn out adequately prepared men in the shortest possible time. It is no easy matter to decide just how much emphasis should be placed on the fundamental sciences, on forest management, on the various phases of wood technology, on engineering, on economics, and on business administration in turning out potential leaders in the wood-using industries.

The forest schools are still in the pioneer period in this field. It is therefore hoped that engineers will be patient with their defects and will give their active and sympathetic cooperation in remedying existing weaknesses and in strengthening the programs of instruction now offered. With such assistance there is no reason why prospective investigators, technicians, and executives should not be given the kind of training to enable them to render maximum service in the wood-using industries.

Uneconomical Minimum-Cost Production[1]

A New Point of View on a Familiar Problem

BY F. E. RAYMOND,[2] CAMBRIDGE, MASS.

RESEARCH has recently disclosed one fact concerning production at minimum cost, quite contrary to that most commonly accepted, which for the moment may well be exemplified by reference to its influence upon the relative advantages of large and small manufacturing establishments. Undoubtedly the presence of both types of enterprise side by side in the same industry has been an important factor in the evolution of the present economic structure in this country. Briefly it can be said that on the one hand the large plant can capitalize all the possibilities for mass production and low cost, while on the other hand the small plant can capitalize its ability to follow rapid changes in buying habits and style or the wishes of its customers, so that through an emphasis on service it may offset any apparent handicap resulting from differences in manufacturing costs.

It is my intention in the present discussion not to lay further stress upon the particular advantages of either type of enterprise, but rather to emphasize one particular factor which relates to the total unit cost of manufacture for each individual product and its influence upon the comparative success of large and small industrial concerns. In fact, the influence of this factor in some instances may be so great as to reverse natural conclusions, should they have been based only upon the usual interpretation of success. By total unit cost of manufacture in these remarks is meant not merely the summation of the direct unit manufacturing cost of any product derived from material, labor, and overhead, but a larger group which includes in addition the cost of carrying inventories, the expense of financing all

[1] A report of progress in the study of Economic Lot Sizes, being conducted at the Massachusetts Institute of Technology in conjunction with the A.S.M.E. Special Research Committee on Management Formulas, presented at the Semi-Annual Meeting, Detroit, Mich., June 9 to 12, 1930, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS as a part of the management session with reference to the relative advantages of large and small manufacturing establishments.

[2] Assistant-Professor of Industrial Research, Massachusetts Institute of Technology. Assoc-Mem. A.S.M.E. Professor Raymond was graduated from Harvard University with the degree of A.B. in 1918 and in 1921 received the degree of S.B. from M.I.T. From 1921 to 1928 he was with the Crosby Steam Gage & Valve Co. of Boston, where he became works manager. He has been at M.I.T. since 1928.

manufacturing operations, exclusive of those incurred by the commercial phases of the enterprise, and such other charges as may be derived from the preparation for or the control of production, all of which may be legitimately prorated to each unit at such times as it emerges from the place of manufacture as a finished product. Without this interpretation minimum-cost production loses its true significance.

It is probably safe to say that in the mind of the average business executive the success of any industrial concern is usually measured by the degree to which the profits earned each year on the capital invested are commensurate with the risks involved in the undertaking. It is assumed, however, in making this statement, that the existence of any concern to which such a measure may be applied has already been economically justified by the service it renders to society and business in general. Since profits are tangible evidence of the ability of the management to maintain an adequate spread between the total unit cost of manufacture and the selling price of any product, and as in most cases the price is hardly ever within the direct control of the manufacturer, it has become quite common for production executives, as their ultimate goal, to strive for the lowest cost production and the minimum wherever possible. If comparisons are made upon this basis, the small-scale producer would seem in many cases to be placed at a distinct disadvantage as his opportunities for cost reduction are not as great as those which are available to his larger competitor through mass-production methods.

However, in reality, is the success of the small concern jeopardized by an inability, purely from a matter of size, to reproduce the low cost of the large-scale producer? Disregarding for the moment the financial structure of a corporation for which the owners of the business are solely responsible, it is quite conceivable that the small enterprise may be able to employ its capital resources to much better advantage than a larger enterprise. Why is it, then, that bankers and investors when judging the future of a corporation are primarily interested in capital turnover and earning power? In other words, a cost-reduction policy should be pursued only so long as it will continue to enhance the earning power of the corporation.

This brings us to the point: Production at minimum cost is not economical. I mean by this that in industries where intermittent processes predominate it is possible to earn a larger annual return from the manufacturing operations on each dollar invested when the quantity of any product which is processed at any one time is smaller than that for which the total unit cost of manufacture is a minimum, all other factors of the business having been fully considered. This situation is entirely due to the fact that the working capital of any concern of this type cannot be as effectively employed when manufacturing schedules are maintained upon a policy of minimum-cost production as they can be when these same schedules are arranged so as to require the smallest average investment of capital and yet provide the greatest spread between the total unit cost for a given scale of production and the prevailing price level.

This fact was discovered as the result of an extended amount of research into the problem of economic lot sizes which has been conducted during the past two years by the Economics Department at the Massachusetts Institute of Technology. In studying this problem to determine the best lot size, it was found that a greater rate of return could be earned upon the capital employed in the manufacture of a lot smaller than that which could be produced at minimum cost, provided that it remained within a certain range below the minimum-cost quantity. In an extreme case it may be quite possible to produce economically, that is, when relative profit margins are considered, a lot one-fifth the size of the lot which would have to be produced to obtain minimum cost. Thus, taking all manufacturing operations of a given plant as a whole, if the total invested capital can be as advantageously employed throughout, it will be possible to maintain the same annual gross return which prior to this time was believed to be obtainable only at minimum cost.

Turning back now to make a comparison on this new basis between large- and small-scale manufacturing plants, it becomes evident that the small-scale producer may be penalizing himself by attempting to compete with the large-scale producer through a policy of minimum-cost production. It is now evident that success may be more fully achieved by the economic utilization of capital resources, and that by the proper regulation of manufacturing schedules, an increased rate of capital turnover and a reduction in inventories, earnings may be obtained which will place the small industry in as favorable a position as could be desired in relation to that held by the large-scale producer. Savings will accrue to him also from the fact that some of the capital which has been formerly required to conduct the manufacturing operations can be invested in more highly efficient machines or new products of equal potentiality for profit, thus providing an additional opportunity to increase the profit margins.

On the other hand, production at minimum cost may operate to the disadvantage of the large manufacturer. Large-scale operations can easily become top-heavy. The investment of capital in highly refined processes which are required to obtain minimum costs may be out of all proportion to the resulting spread between cost and price. In such instances there is a tendency to produce large quantities at a time in order to distribute certain fixed charges over the greatest number of units, and this policy will probably lead, if it has not already done so, to slower moving inventories and a less rapid turnover of capital. In fact, it may evolve that the present expenditure of capital has been unwarranted since the anticipated gain through mass-production methods, if volume is the chief objective, has failed to achieve a return upon the investment which is equivalent to that attained by a smaller manufacturer even though the costs for the latter may be somewhat higher.

In making these statements, which may seem radical to some, I do not wish to imply that a sound cost-reduction policy is ever unwise. Minimum total unit costs have a most decided application to the selection and adoption of the best manufacturing process but they do not have any relation to the best method of conducting or controlling the manufacturing operations except in one limiting case. This will occur when continuous methods of manufacture can be established owing to the fact that the rate of consumption or sales has become equal to the rate of production, because under these conditions only will the point for minimum cost be found to coincide with that for the economical utilization of capital where the greatest return can be realized. Even at that, this situation may not hold for long, because as machine designers continue to introduce new manufacturing equipment with greatly increased capacity, the large producer may find himself reverting, by force of circumstances, to intermittent processes unless he has the ability to augment his present sales through means which will result in an even more aggressive marketing policy.

In conclusion it should be remembered that both the large-scale and small-scale producer must, in the future, be able to differentiate between the two parts of a policy of production at minimum cost as it may contribute to larger profits or as it may be employed as the basis for the adoption of new equipment or processes, if a reasonable and comparable rate of return is to be earned upon the capital employed by each. Thus in the long run the industrial executive who is willing to profit by proved economic facts will be able to justify his position in business whether he operates on a large or small scale.

Management of the Small Manufacturing Plant: Its Characteristics and Advantages

By CROSBY FIELD,[1] BROOKLYN, N. Y.

BEFORE proceeding to a discussion of the management of the small manufacturing plant three questions must be answered: First, what is a small plant? Second, is there a sufficient number of small plants to warrant consideration? Third, are their chances of continuing to operate sufficiently great to warrant an investigation into their characteristics of management?

What Is a Small Plant?

Naturally any question of size is purely relative, and there are many standards of comparison possible. The most frequently used are:

(A) Average number of wage earners employed
(B) The power consumed
(C) The value of production (sometimes modified so as to use instead the value added by manufacture)
(D) The capital invested.

When considered by any one of these standards, it will be found that plants group themselves by each standard in a similar fashion. These all show a larger number of establishments in certain groups than in others, although the relationships existing between groupings of plants according to the various standards may not be the same.

Again, these standards have to be considered from the viewpoint of comparison of the size of the plant, considering all manufacturing plants in the country as a whole or only those in the industry under consideration.

If any one industry be considered at various times over its life, its growth can be considered in four phases having quite distinct characteristics. These four phases are:

1 *Pioneer.* In this phase all of the four characteristics increase, and usually each shows very closely the same percentage of increase. This is the phase of the very small plant.

2 *Expansion.* During this phase (A) and (B) continue to increase, but (C) and (D) increase very much faster. This is the phase in which large and small plants are both found, and the total number of plants is relatively numerous to that to be found in the other phases.

3 *Consolidation and Stabilization.* In this period (A) may even show a decrease or, at any rate, a very slow increase; (B) usually increases quite rapidly; (C) increases slowly; and (D) tends to increase slowly or remain stationary. In this phase the number of plants decreases, but the average size increases.

4 *Disintegration.* During this period the industry is losing place to other newly arriving industries. The tendency is for all of the foregoing to show a decrease; (A) and (B) rapidly, (C) less rapidly, and (D) very slowly, sometimes remaining constant. In this period the average size of plant decreases. In rare cases the number of plants may actually increase, showing a transplanting to new locations and subsequent building up there, after the fashion of a new pioneer phase.

Obviously the main objective of management in each of the four phases may be quite different, but, as is shown farther on, certain characteristics, predicated upon size, predominate.

In this paper the index used is that of average number of wage earners, for two principal reasons:

1 The majority of the problems of management revolve about the question of labor, and it therefore predominately influences the characteristics of plant management.

2 The number of laborers is a common denominator not involving variation in price of product or in daily wage rates; it is therefore more general than the others when plants in various parts of the country or during different years are compared.

Although authorities differ greatly in their estimate of what constitutes a small plant, there is a tendency to consider one employing 250 employees or less as being small. This group comprises more than 90 per cent of the total number of manufacturing plants, although producing only a little more than half of the total output. It is also ascertained that there is no tendency for the small plant to disappear, on the contrary, it would seem as though it was even better than holding its own. The reason that it is holding its own is twofold: First, there is a size of plant that is most efficient at any given time and at any given stage of the industrial arts, and this size of plant is apparently small enough to lie within our definition of small plant in a great majority of industries. Second, our wants are constantly changing and the plants that are built to fulfil these wants must naturally grow from the very smallest size in the pioneer stage to the still usually small-size plant to be found in the expansion stage.

Protective Influences

What are the criteria of success in management? Many have been proposed, but the two that apparently have the most widespread acceptance are a continuing increase in gross volume accompanied by a continuing increase in net profit. The ratio of the latter divided by the former need not necessarily increase, nor even remain constant, to show success; but too great a decrease indicates a change in conditions to be pending that acts as a forerunner of possible difficulties.

These criteria come as judgment after the act; what can be used before the act as a prediction of result?

It is well recognized, as Kimball[2] states, that "every manufacturer must expect to rest his chances of success on one of three general factors; namely, monopoly, quality, or price." (Some authorities consider as a separate factor what they call

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[1] Vice-President, Brillo Manufacturing Company; President, Flakice Corp. Mem. A.S.M.E. Colonel Field holds the degrees of B.S. from New York University, M.E. from Cornell University, and M.S. from Union University. From 1912 to 1914 he was associated with the General Electric Co., and during the following year was engaged in private consulting practice in New York City. From 1915 to 1917 he held the position of chief engineer of the Standard Aniline Products, Inc., resigning to enter the Ordnance Department of the U. S. Army. Upon his return to civil life he became engineering manager of the National Aniline & Chemical Co., Inc.

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[2] "Industrial Economics," Dexter S. Kimball, 1929, p. 5.

service, the ability to deliver the material when or where wanted, or in the special shape desired.) As is usual with general factors, they must be studied carefully in their specific aspects as applied to the individual case before rating their influence. Thus monopoly, whole or partial, may be due to patents, to strategic location, to favorable sales combination, to indirect control of the purchaser by influences other than those due to the business in hand, to reciprocity, to local pride in a local industry, to transportation peculiarities, to franchise or other legislative control, and countless other factors.

Looking at these general factors from another viewpoint, and their numerous interrelations, it is quite likely that they in turn are but aspects of a still more general factor. This more general factor further predetermines the proper size of plant, of selling organization, of financial structure. The author ventures to give this factor a name, with full realization of the fate that usually falls to those who risk too broad a generalization, especially when accompanied by attempted definition of new terms, because it is believed the advantages of having such a term to apply to the daily solution of management problems warrants the effort.

Manufacturing plants and their selling organizations exist for the purpose of supplying commodities to fulfil human needs. With each human being the specific definition of that need varies slightly from that of his neighbor, but it is possible to group individuals into classes whose needs can be fulfilled within a range for the fulfilment of which it is possible to design a plant and organization. The only excuse for such a plant is that it has selected a field for operations in which it has advantages which render it unique. Unique is defined[3] as "being without a like or equal; single in kind or excellence; sole." The noun uniqueness has a general overall flavor; hence the term "degree of uniquity" is suggested as implying a relative degree of compliance with its original or logical uniqueness. A firm may be unique in the articles it produces, the process of manufacture, the way it sells, the territory in which it sells, the trade to which it sells, its fashion of shipping, the method of receiving its pay, its advertising, or even the power given it in the public mind by the personality of one of its members or employees. The degree of uniquity it enjoys is demonstrated by its degree of monopoly, or the quality or price of its products, and is accompanied by its growth in volume and profits.

It naturally follows that a plant should be as large as it can without sacrificing too many degrees of uniquity, for there is no room for two plants having the same degree of uniquity, the uniqueness being measured from the viewpoint of the integration of the territories being served. One or the other must gradually withdraw from parts of territory or types of customer, thus changing the relative degree of uniquity.

As the plant grows, there is constant temptation to take on new lines, to expand territory, or to cut prices. Each such step is accompanied by a decrease in the degree of uniquity, with its subsequent dangers. Growth by expansion of territory is usually the least dangerous, because of the universality of similar needs among our countrymen everywhere, but every small enterprise pays dearly for its right to claim "national distribution."

The realization of the need for a large degree of uniquity in a small plant to protect it from competition is one reason so many small plants start as manufacturers of a specialty. If fortunate enough to select a specialty that is going to grow into a huge basic industry, such as steel, automobiles, etc., the growth of the plant will be great. It is, however, not unusual for a specialty of a small industry to grow to a size larger than the original industry and to completely overwhelm it, changing not only its entire aspect but the ownership of the controlling companies. This is often accomplished by acquiring a considerable degree of uniquity in only one phase of operations, such as the discovery of a new use by a slight modification of manufacture or marketing, or by a change in manufacture due to an invention.

Every plant, large or small, should devote its attention to maintaining or even increasing its composite degree of uniquity, and in certain phases the advantage therein lies entirely with the small plant. The large company must have volume; to get volume it must sell everybody, it must sell everything (i.e., a complete line), it must sell everywhere. Each approach to universality in each phase lowers the degree of uniquity, save perhaps in actual production where the greater amount of available money may render possible the purchase of a greater degree of uniquity due to research on product and process. It is a strange commentary that the large companies availing themselves of this method of obtaining uniquity is relatively small.

There are certain advantages which must ever remain with the large plant. Foremost is in obtaining favors that money can buy. This gives the larger plant a tremendous superiority in bargaining power, not only in the buying of its raw materials at the lowest possible prices, but also in competitive selling, which after all is a kind of buying where the flow of money is reversed. Not only in selling its products, but in selling its securities and in patent litigation, the money power of the large plant makes a formidable obstacle to the small plant against which there is only one weapon for the small plant to use—initiative almost mounting to daring, in strengthening its position in so far as degrees of uniquity are concerned.

From the viewpoint of the small plant, in sizing up its opponent, the large plant, it must consider it very much from the viewpoint of the inferior army in combat. The victory does not go to the general with the largest forces nor the largest supply, but to the one who can get, to paraphrase General Forrest, "The mostest men [and the mostest supplies] thar fustest."

The small plant that endeavors to compete with its larger neighbors by making everything that the larger plant makes, puts itself in a very unfortunate position. The strength of the small plant as detailed is essentially specialization, either specializing in product or in method of manufacture, or in marketing. This specialization in marketing may comprise intensive work in a limited territory or a new and novel means in a larger territory. The specialization in the method of manufacture usually comprises the development of special machinery, preferably protected by patents, affording the small plant an opportunity to realize on its manufacturing cost difference. All these advantages merely increase its uniqueness when compared with its larger competitors.

A plant normally starts, therefore, because it is in a unique position to fulfil certain needs. This composite degree of uniquity is composed of numerous factors, each representing a degree of uniquity of one activity of this plant compared to the same activity of other plants. The precise numerical figure for the measurement of this degree of uniquity would be difficult to arrive at, but may be normally considered to be the unit dollars-and-cents advantage over other ways of fulfilling that need. As the plant grows it soon arrives at a place where due to expanding business one of the component factors of the composite degree of uniquity becomes greatly diminished. It then becomes a matter of much concern whether to still further increase the volume and thus noticeably diminish the overall degree of uniquity or whether to maintain that degree and permit the volume to remain constant. The ultimate size of plant,

[3] Webster's New International Dictionary, 1927, Merriam, p. 2242.

therefore, should be that size which can produce the greatest volume with the least marring of its degree of uniquity.

Generally speaking, there is room for only one plant having a certain degree of uniquity; consequently, the plant should aim to become the "largest of its kind" within the shortest possible time after starting. This, of course, is just another way of saying that the plant should be the largest having that degree of uniquity.

One movement that has gained considerable momentum in the past decade has been the so-called "integration of industrial operation."[4] This is an attempt to obtain the advantages of volume and of uniqueness in the same organization, maintaining the plants of a size and number tending to the greatest degree of uniquity and simultaneously providing an overall volume that warrants those advantages that accrue alone to size. The integration may not only be along the matter of plants, but also sales organization or other aspect of the business. In each case the aim will be found to be the same, and the greatest advantage accruing to the integrated industry is its bargaining power and those other advantages that money alone can buy.

Characteristics of Personnel

Specialization as a method of strengthening the small plant's uniqueness has been emphasized, but when the personnel is examined, a strange paradox presents itself. For success, the small plant requires the greatest specialization in product and methods, and yet the greatest versatility in the mental attributes of the men concerned with management. A few moments' reflection will show this. A man's time may be occupied either by performing one function and applying it to a number of things (the so-called functional organization) or by performing several functions connected with some one thing. When the plant is small enough the man at the head must naturally perform all three functions in the tripod of manufacturing—to wit, production, sales, finance. As the plant grows larger, specialization, or rather functionalization, takes place, and the president hires a factory manager, a sales manager, and other functional heads, but he himself in the small plant must perform all these functions.

One of the characteristics, therefore, of the personnel of a small plant is its versatility. Each man in the plant, from president to foreman, will be found to perform a larger number of functions than a man of corresponding position in a large plant. Indirectly this versatility of mind points the reason for so many failures in small-plant management. Because a man is versatile he is inclined to get into several businesses or try to make his business go into related lines. He does this not only because of his desired increase of income, but also because of this versatility of mind.

Strange to say, this versatility of mind is not so common in an industry just beginning, and perhaps that is one of the reasons so many small plants are never able to survive the pioneer phase. The hardships of pioneering require a degree of perseverance that cannot even politely be termed anything but obstinacy. Obstinacy may not necessarily imply a low order of intelligence, but the results of its application in practice usually preclude the acquisition of that culture which makes for versatility. Culture and intelligence are not necessarily one, but are more often found together than either one by itself. Certainly the lack of income in an industry not yet past the pioneer stage does not attract men having that culture and who are usually comfortable in a better established line. That "intelligent patience"[5] which is the prerequisite for all research and other pioneer work fades rapidly when confronted with an empty stomach.

This required versatility is well brought out by Cole,[6] who compares the simplicity of ship navigation in two dimensions, or even that of the air in three dimensions, with that of a manufacturing plant with its manifold problems—it is N-dimensioned. In any one of its numerous dimensions may lie the hidden rock of failure.

Alford and Hannum[7] in their startling Table V show that the small plant has the advantage in the output per man. Just why this should exist is of course a matter subject to many opinions, but the author firmly believes that one of the principal reasons is the fact that those responsible for the details of operations affecting costs are closest to the profit and loss in the industry. In other words, there is no incentive like ownership in an enterprise, and when the manager is part owner and when the superintendent and foreman share in the form of bonuses from the profit attained by their operation, then each has the greatest incentive for efficient management. It is not that there is any particular difference in the desire or willingness on the part of the men, but the cause and effect are so closely related and the one follows the other so promptly that there can be no mistaking their relationship. In a small plant no mystery exists in the minds of the men making and selling the product of the relation between costs and profits. There are no central office charges or huge overheads to be absorbed, and in their absorbing to distort charges. Each foreman can figure concretely how many of a kind he must make with a new machine in order to pay for it or not to affect either the profits of the company or his own bonus.

In the management of the small plant the keeping of the overhead to a minimum is a prime requisite. There is nothing that chews up profits quicker than useless records, and records all have that well-known tendency to become useless unless they are constantly used. In order to be constantly used, they must be of prime interest to those most concerned. In one plant the policy has been to keep no basic records unless somebody's pay depends on it. All the production records are under the paymaster, and it is indeed rare that errors enter, for any error is going to affect somebody's pay, and naturally if this is affected in the wrong direction an immediate howl is made by the party affected. If, on the other hand, they are affected in the other direction, then the foreman and his bonus create the other situation. A summary of these records is studied by the operating committee twice a week at a meeting which is primarily for the study of these records, which have of course been boiled down by the paymaster into summary sheets. At this meeting any other business that may be pressing is brought before this committee, but pains are taken to let the committee understand that in working as a committee it is purely advisory, the responsibility for functioning remaining with the individual.

Type of Organization

This mention of the "operating committee" brings up the question of the type of organization for the small plant. Any

[4] See "The Integration of Industrial Operation," by Willard L. Thorp, Census Monograph III, 1924.

[5] William H. Vermilye, Vice-President, National Aniline and Chemical Company, in conversation with the author, used this apt phrase.

[6] Cole, D. S., "Capitalizing the Advantages of the Small Factory," 1925, *Indust. Manag.*, vol. 69, pp. 208–12, ref. 23, pp. 291–5, ref. 21, pp. 360–4; vol. 70, pp. 40–5, 265–9, vol. 71, pp. 27–31, 106–11, 235–40, 311–16; vol. 72, pp. 54–9, 283–7. Answers, among other important questions, "Can the small shop survive, and how?" Takes up such subjects as the importance of a fixed policy, material in the small shop, the importance of the product, supercompetition, and the small plant. Is the "complete line" advantageous? Goodwill as a permanent asset, cooperative buying and selling, some aspects of the competition for labor.

[7] Alford and Hannum, "A Basis for Evaluating Manufacturing Operation." MECHANICAL ENGINEERING, vol. 51, no. 3, March, 1929, pp. 181–185.

manufacturing organization naturally divides itself along the lines of its three principal functions—sales, production, and finance. In the smallest-size plant all functions are headed up by one man, who frequently takes on as silent partner a financial backer. In the larger size of small plant the production or sales is alone handled by this one man, the other functions being handled by another, who also acquires a substantial share in the enterprise. From this split-down in each of the two operating departments, sales and production, the organization is decidedly line, the versatility of the key men being depended upon for staff functions. In the next larger-size plant, certain staff functions may be split off, generally a superintendent to handle labor, a plant engineer to handle equipment design, construction, and sometimes maintenance, and the office, including paymaster, and sometimes purchasing agent. Similarly, the sales organization is separated from credits, and territorial divisions enter.

Depending upon the nature of the business another function becomes sometimes most important, particularly in those industries which are of a contracting or jobbing nature. That is the function of designing for proposals or estimating. Whether or not the estimator be part of the sales organization or part of the factory organization depends greatly upon circumstances, but normally will be found to be under the engineer who in a small plant is both plant engineer and design engineer.

Our typical small plant now has 100 to 250 employees, and if it continues to grow it must be classed as a large plant. Our key personnel must remain versatile, and comprises only seven men, enough still to share directly in the profits by having a share in the ownership. These men are the chief executive, sales manager, credit manager, production or factory manager, superintendent, engineer, and purchasing agent. Further profit sharing among territorial sales managers and foremen is easily obtainable by means of commissions and bonuses, the close contact of the heads with affairs and men rendering such procedure profitable. This gives the greatest incentive to effort, and, as has been stated, is probably one of the reasons for the greater efficiency of the small plant.

For committees, which should be purely advisory, only two in the factory, safety and operating, and one comprising sales and credit, are desirable. At these conferences hidden difficulties are frequently brought out and settled.

Research and Development

Since the small plant must keep down overhead, it suffers from lack of staff, and it therefore would seem that the small plant is the ideal client for the professional consultant. Obviously the small plant cannot compete with the staffs and laboratories of the large concern, having a staff of a caliber and size to take care of all their needs; nevertheless, the retaining of professional consulting services and realizing upon them forms one of the most difficult problems of the small-plant manager. The small plant must specialize, and by conquering its specialty it very soon gets out of the depth of the professional consultant who may then become even something of a liability. On the other hand, the small plant cannot be expected to keep in touch with the advance of the art as a whole; hence a compromise must be effected whereby the small-plant manager is brought down to date by the consulting expert on all matters connected with the art as a whole, retaining for his own small staff the specialization work that pertains to his own manufacture.

This requires, of course, versatility on the part of the plant manager, and it may further be displayed not only in the hiring of engineering and manufacturing consulting services, but further in the retention of other types of professional consultants, such as patent attorneys, auditors, and the like. The man at the head of the small plant must be versatile enough to make proper judgments when presented with the technical facts and advice of the various consultants he should retain.

One place that the small plant very frequently falls down is in the development of its own machinery and equipment. It is too easy to buy standard equipment and operate it. In so doing the plant is not putting itself in any way in a position to compete with its rival, who is of course going to receive the benefits of the same machine. There is no resulting favorable differential in uniqueness obtained. The modification of a standard machine to produce a specialized product is one of the surest ways that the small plant can achieve success.

Ranck[8] in an able article tells how his concern obtained great advantages in a specialized product by developing machines twice as large and able to handle material twice as wide as could be provided them by the standard machinery manufacturers. This resulted in a small plant having the largest machines and enabled it to undertake work that the large plants with their small machines could not do. Mr. Ranck, as might be expected from such a course, evolved the following three suggestions for a small plant:

1 Make the best product
2 Watch costs; fight them with daring
3 Watch shifting markets, particularly with respect to the salability of the product.

Distribution Effects

Depending as it does upon volume, the large plant naturally tends to manufacture more of its own raw materials, which means more products to use or sell, which means an ever-increasing line of products, marketed more and more upon a price basis and with constantly increasing fixed capital investment. All this tends toward a rigidity of operation, a building up of inflexible policies and other attributes that render it comparatively immobile, while the small plant can succeed better because it can move quicker. In order to maintain its mobility it must be in close contact with its customers.

Generally speaking, the more successful small concerns are found closest to the ultimate consumer, working back into production of its raw materials only as they increase in size, and the larger concerns are found nearest the crudest materials, such as mines or other original sources of raw material. This is good policy in that it permits the more ready establishment by the small plant of that uniqueness referred to. The contrary policy of manufacturing for a large plant, thus becoming a so-called "satellite plant," is frequently profitable, but exceedingly hazardous.

Distribution costs form an increasingly important share of the total. In selecting the right customers and the proper market the small concern has several advantages; the large concern seeking to dominate the line must sell everybody, and in selling everybody takes many accounts at a loss, whereas the small concern with limited output can be more selective in its accounts.

Cole[6] refers to the most usual "entangling alliances" to be avoided as dependence upon a single or uncertain source of supply of raw materials, a single product, or a single customer or outlet. Yet if the composite degree of uniquity be great enough, a single product is often the very best guaranty of continued success. In order to accomplish this, however, it must be protected by a trademark and a distribution that make it difficult for a competing brand to get into the ultimate consumers' good graces.

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[8] Ranck, Z. W., "I'd Rather Run a Small Business." *Factory & Indust. Manag.*, vol. 78, 1929, pp. 1063–5.

International Unification of Standard Fits

A Résumé of the Historical Background and Efforts to Unify Existing National Systems of Fits Between Cylindrical Parts

By JOHN GAILLARD,[1] NEW YORK, N. Y.

SERIAL or mass production of machines and other objects requires standardization of the fits between their component parts. These parts must be interchangeable in order to permit ready assembly and replacement.

A highly developed industrial country cannot do without a national standard system of fits because many industries are closely interwoven, their particular products being assembled into one final product. In addition, national standardization of fits makes it possible to standardize, in a national way, tools and equipment, such as reamers, drill bushings, etc., required for the establishment of standard fits, and also of the gages required for controlling them.

In our machine age, with an international exchange of goods, the establishment of an internationally unified system of fits has become an important problem. Certain developments now taking place under the auspices of the International Standards Association,[2] are interesting enough to be brought to the attention of groups in this country, the more so as, since the fall of 1929, the industry of this country is represented on the I.S.A. through the American Standards Association. This body approved in 1925 a Tentative American Standard on Tolerances, Allowances, and Gages for Metal Fits established by a technical committee appointed under its procedure and sponsored by the A.S.M.E.

At an international conference held in 1926 in New York, where the basis for the I.S.A. was laid, a series of technical subjects was discussed in special meetings. In one of these, the problem of fits between cylindrical parts was dealt with. Each delegate explained the status in his country and the consensus of opinion was that it seemed possible to smooth out the differences between the several national systems then in existence.

When, in 1928, the I.S.A. was formally established at a meeting held in Prague, a technical committee on fits was appointed under its auspices to draft a proposed system of fits that would be acceptable to all countries concerned. It was explicitly stated that one of the conditions to be answered by the new system was that parts made in accordance with it should be interchangeable with those made in accordance with the existing national systems.

A subcommittee consisting of delegates of the national standardizing bodies in Czechoslovakia, France, Germany, Sweden, and Switzerland, was appointed to draft a proposal. The secretariat of the international work on fits was entrusted to the German body, Deutscher Normenausschuss. Between 1926 and 1928, this organization had performed much valuable preparatory work by systematically collecting data on all of the national standard systems in existence or in course of development, and by elaborating, on the basis of these data, comparative graphs in order to find out in how far the existing systems possessed identical features. Early in 1930 the subcommittee had elaborated a first proposal.

The proposal, which will be submitted to American industry by the American Standards Association, is largely based on the German national system of fits, the so-called DIN[3] fits. For this reason a brief review will be given of the history of the development of this system and of its introduction into practice in German industry, in the course of the last ten years.

Development of the German National System

In 1917 when German industry started a strong standardization movement, one of the first subjects assigned to a technical committee was that of fits between cylindrical parts. Up to 1917, great diversity had existed in fitting practice. Gages were made to reference temperatures of 0, 15, or 20 deg. cent. (32, 59, or 68 deg. fahr., respectively). Some organizations applied a unilateral system of tolerances, others a bilateral. The numerical values of allowances and tolerances differed from firm to firm, if not from department to department in the same organization. Under these conditions, there was no question of systematic assembly between parts made in different plants, let alone of standardization, in a nation-wide way, of tools and gages.

The German national system of fits, started in 1917, was completed in 1920. The work had been started with fine-grade fits, that is, with a group of fits most commonly used in the mechanical industry as a whole. Precision-grade fits were then added for the use of the machine-tool industry and of other work requiring fits of a more exacting nature than the fine-grade ones. Following this, medium-grade and coarse-grade fits were elaborated, the latter to comply, for example, with the wishes of the builders of railroad cars.

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[1] Mechanical Engineer, American Standards Association. Mem. A.S.M.E. For several years Mr. Gaillard has been closely associated with the national and international phases of standardization work in different branches of industry. He has made a special study of standard systems of fits, and obtained many of the data used in the present article during a recent trip to Europe. In May, 1930, he took part in conferences held in Paris under the auspices of the International Standards Association (I.S.A.), a federation of eighteen national standardizing bodies, of which the A.S.A. is a member. Later he visited the German national body, Deutscher Normenausschuss, in Berlin, and several individuals and organizations prominent in the German standardization movement.

[2] The International Standards Association, I.S.A., is a federation of national standardizing bodies. Its main purpose is the systematic exchange of information between its member bodies concerning national standardization work going on in their countries so that discrepancies between national standards for the same object may be avoided or eliminated in all cases where this appears to be feasible and desirable.

The present membership of the I.S.A. comprises the national bodies in the following 18 countries: Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Germany, Holland, Hungary, Italy, Japan, Norway, Poland, Roumania, Russia, Sweden, Switzerland, and the United States. The secretariat of the I.S.A., originally established in Zürich, is now being transferred to Basle, Switzerland.

[3] The symbol DIN, an abbreviation of Deutsche Industrie Norm, meaning German Industrial Standard, is now generally used in Germany for designating any object complying with a standard approved by the German national standardizing body, Deutscher Normenausschuss. The symbol DIN has been registered in the name of the German body and its prestige is constantly growing.

DIN FITS

. The main features of the German system in its present form are as follows:[4]

The reference temperature for gages, etc., is 20 deg. cent. (68 deg. fahr.), the same as in the American standard system.

Unilateral tolerances are used, i.e., the tolerance is measured in one direction only. Furthermore, the general reference or zero line from which all measurements are made is the nominal size of the part concerned. All of these features are also incorporated in the American standard system.

The German system was designed from the beginning so as to comprise both a basic-hole and a basic-shaft system. In the former, the basic size of the hole is kept constant, for a certain series of fits, the difference in fit being obtained by varying the size of the mating shaft. In the basic-shaft system, on the contrary, the basic size of the shaft is kept the same for a certain series of fits, the size of the mating hole being varied to produce the desired fit.

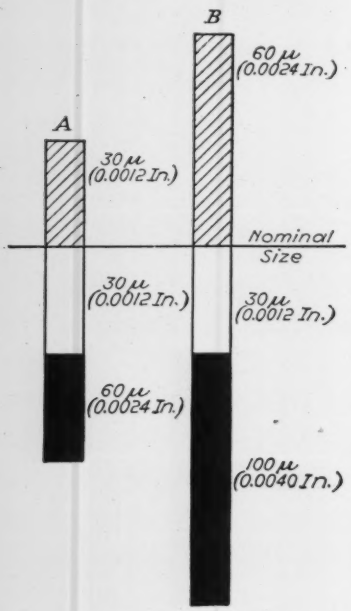

FIG. 1 TWO GERMAN STANDARD FITS OF THE SAME CLASS (RUNNING FIT) BUT OF DIFFERENT GRADE (FINE AND MEDIUM)

Both systems were adopted side by side in the German standard, on the ground that it depends on the nature of the product, and on the manner in which it is manufactured, whether one or the other sub-system will prove to be the more advantageous from the combined technical and economical points of view. In fact, it cannot be said, in general, that either the basic-hole or the basic-shaft system is preferable. In many cases the question of which system should be chosen is a rather difficult one to answer, requiring careful weighing of a goodly number of correlated factors. Therefore the Germans decided that the national standard ought to enable every manufacturer to select the sub-system that is most appropriate for his particular needs.[5]

As to the ratio between the applications of the two sub-systems by German industry as a whole, one gage manufacturer stated to the writer that 80 per cent of orders for gages is for those to be used for fits in the basic-hole system, and 20 per cent for gages for basic-shaft fits. Consequently, this manufacturer keeps the former gages in stock, but not the latter. The fact that 20 per cent of the gages are used for fits in the basic-shaft system confirms the correctness of the viewpoint taken by the German committee, that the requirements of those needing a basic-shaft system should not be neglected in establishing a national standard system of fits.

In addition to the concept "class of fit"—the class of a fit depends on its allowance[6]—the Germans adopted formally "grades of fit." The grade of a fit depends on the relative magnitude of the tolerance on the parts. That is, if two loose fits A and B, for example, have the same permissible minimum clearance (see Fig. 1), while the tolerances on parts A are smaller than those on parts B, fit A is of a higher grade than fit B. Evidently, the possibility of variation in actual clearance is smaller in case A than in case B.

The Germans established four grades of fits, each grade comprising a series of fits of different class. The DIN system gives altogether 22 completely specified fits in each of the two subsystems. In addition to these, other combinations between standard holes and shafts may be made, if necessary.

It should be emphasized that the relatively large number of completely specified fits has been adopted only with a view to answering the widely varying requirements of national industry as a whole. Each branch of industry will pick, from the 22 standard fits, those which suit its purpose best. In other words, it is a rare exception—occurring only in very large concerns manufacturing products of a widely different nature—that a single firm has use for all of the German standard fits. For the same reason, it need not be feared that the co-existence of the basic-hole and the basic-shaft systems will cause confusion.

The means of controlling and maintaining the standard fits were also standardized in the German system by laying down, in the standard, the manufacturing tolerances and the permissible wear for different kinds of gages—working, inspection, acceptance, and reference gages. Consequently, it became possible for German gage manufacturers to keep standard gages in stock. By simply ordering a working plug gage, 15 B DIN 306, the user will receive a gage for a hole with a nominal diameter of 15 mm.; manufacturing limits of the hole, 15.000 and 15.018 mm.; manufacturing limits of the gage, 15.000 and 15.0045 mm. for the "go" side, and 15.0203 and 15.0157 mm. for the "not go" side. Also, this gage will have a color mark in bright blue, indicating that it serves for checking a fine-grade fit.[7]

The fact that standard gages are kept in stock by gage manufacturers, greatly promotes the use of the standard fits. If a firm which so far never has applied limit gaging wishes to make a start in this field, it will find that standard gages are most easy to obtain and at the lowest cost. Under such conditions, there is no reason why such firm should look for anything else than the national system of fits.

INTRODUCTION OF THE DIN FITS INTO PRACTICE

German industry has adjusted itself in a remarkably short period of time to the German national standard. This was due, in a large measure, to the close cooperation between manufacturers and users of limit gages.

Progress of the standard was so rapid that an inquiry held as far back as 1925 showed that at that time 95 per cent of the gages ordered in Germany were specified to comply with the DIN system. During a visit paid by the writer this summer to several important German organizations, it appeared that orders for gages that are not in accordance with the German standard were negligible nowadays. The statement was made that the percentage of orders on DIN gages was at the present time well over 99 per cent.

The DIN fits have been adopted by more than 1000 German organizations, this number comprising most important industrial concerns. About two years ago, a canvass was held by the

[4] A few revisions have been made since the original system was adopted in 1920, but these have not changed its essential character.

[5] The present American standard gives the basic-hole system exclusively. However, the need for standard fits given in a basic-shaft system has occasionally been brought to the attention of the A.S.A.

[6] The "allowance" is the minimum permissible clearance or the maximum permissible interference between the mating parts, according to the definition in the American standard.

[7] The symbol DIN 306 refers to the standard sheet on which the gage in question is specified, the symbol B to the grade of fit.

German body in order to find out in how far the DIN system had given satisfactory results in practice. The outcome of that canvass was very gratifying to the originators of the system. A number of firms, active in different branches of the mechanical and electrical industry, declared that the DIN system had been successfully used in their plants, in some cases since its formal approval by the national standardizing body in 1920.

Foreign National Standards Based on the German System

Much attention was given to the German system by the national bodies of other countries. In fact, the DIN system was taken over, either in its entirety or with a few minor changes, such as in Norway, where certain fits were left out as being superfluous for industry in that country, by the national standardizing bodies of Austria, Belgium, Holland (the DIN system supplanted here a national standard previously adopted), Italy, and Norway.

However, the real test of foreign appreciation of the German system came when the establishment of a draft for an I.S.A. system was discussed by the subcommittee already mentioned. In that committee, Germany is the only country that has adopted the DIN system France has no national standard as yet. The Czechoslovakian member, Professor Sawin, criticized certain features of the DIN system a few years ago. Sweden and Switzerland have adopted national systems that are different from the German.

Therefore, the fact that the other four countries agreed to a draft for an I.S.A. proposal, based essentially on features of the DIN system, seems to prove that the latter was considered to have worked out well in actual practice. On the other hand, the German experts agree that the changes made by the international subcommittee in that part of the DIN system that has now served as the basis for the present I.S.A. proposal are decidedly improvements, and that these improvements might not have been made for several years to come if the matter had not been taken up internationally. It is therefore interesting to note

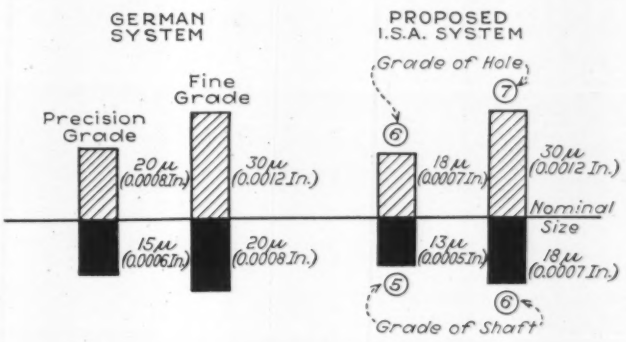

Fig. 2 Precision- and Fine-Grade Basic Holes and Shafts in German and in Proposed I.S.A. Systems
(Range of diameters, 50 to 80 mm., inclusive.)

that in this case international cooperation has led not only to the first step required for straightening out discrepancies between existing national standards, but also to further improvements in a standard which evidently had reached a high degree of perfection. The proposed changes in the DIN system have been given full approval by German industry in a gen ral conference recently called by the German national body.

Main Features of Present I.S.A. Proposal—Grades and Classes of Fit

The proposal now to be laid before the member bodies of the I.S.A. refers to two series of fits meant to cover the same ground as the precision-grade and fine-grade fits of the DIN system. The program comprises three more series of fits, two of which are meant to serve in lieu of the DIN medium-grade and coarse-grade fits, respectively, while the third is a new grade lying between the DIN fine-grade and medium-grade fits.[8] Possibly, a further additional grade of fits will be inserted between the medium-grade and coarse-grade fits.

For easy comparison, the tolerances on basic holes and shafts, both of the precision grade and the fine grade, are shown in Fig. 2 for the DIN system and for the proposed I.S.A. system. The tolerances are expressed in microns[9] and apply to parts which have a nominal diameter between 50 mm. and 80 mm., inclusive.

The fine-grade hole has been taken over from the DIN system without change, whereas the tolerance on the fine-grade shaft has

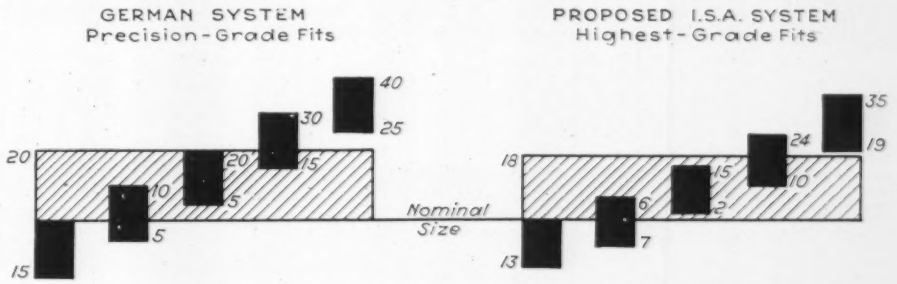

Fig. 3 Tolerances and Allowances of Highest Grade Fits (Basic-Hole System) in German and Proposed I.S.A. System
(Range of diameters, 50 to 80 mm. inclusive. Values in microns: 1 micron = 0.001 mm. = 0.00004 in.)

been slightly reduced—from 20 to 18 microns in the range of sizes under consideration.

The precision-grade hole and shaft have both been refined by a reduction of their tolerances.

The positions of the tolerances with regard to the reference line (nominal size) are also important, as they determine the allowances of the fits.[10] For the fine-grade fits, these positions have essentially remained the same in the proposed I.S.A. system as they are in the DIN system. For the precision-grade fits, however, the I.S.A. tolerances lie somewhat more closely to the reference line than the DIN tolerances (see Fig. 3). In other words, whereas the fine-grade DIN fits have undergone a refinement consisting almost exclusively in the reduction of the tolerances on hole and shaft, the precision-grade DIN fits have been refined both by the reduction of hole and shaft tolerances, and by a shift of these tolerances in the direction of the reference line.

While, for the sake of facility in building up a system of fits, the concept "grade of fit" has still been used, in elaborating the I.S.A. proposal, it is the definite understanding of the subcommittee that the formal subdivision of the fits on the basis of their grade, and even the explicit specification of classes of fit, should be abandoned. That is, the proposed I.S.A. system will be based on the principle of letting the user of fits select the combination of a standard hole and shaft suitable for his purpose.[11]

[8] This new grade of fits is meant to eliminate such objections against the DIN system as were raised a few years ago by Professor Sawin.

[9] The micron is usually indicated by the Greek letter μ (mu). One micron equals 0.001 mm. or about 0.00004 in

[10] For definition of "allowance," see Footnote 6.

[11] In the German and also in the American and other national standard systems of fits, combinations of holes and shafts other

The concept "grade" will be conserved with regard to a hole or shaft. According to the I.S.A. proposal, the requirements of all fits—that is, of the two grades of fits now worked out, and of the three further grades still to be elaborated—will be covered by seven grades of holes and shafts. These are represented in Diagram A of Fig. 4 showing the numerical values of the tolerances on parts—holes or shafts, as the case may be—with a nominal size between 50 and 80 mm. inclusive. Diagram B, Fig. 4, shows the five grades of holes and shafts on which the American standard system of fits is based, for parts with a nominal size of from $2^3/_4$ to $3^1/_4$ in. inclusive.

The proposed I.S.A. grades of holes and shafts have been numbered 5 to 11, inclusive. The reason the grade with the closest tolerances has not been numbered 1, but 5, is that still closer tolerances are to be used for different kinds of gages.

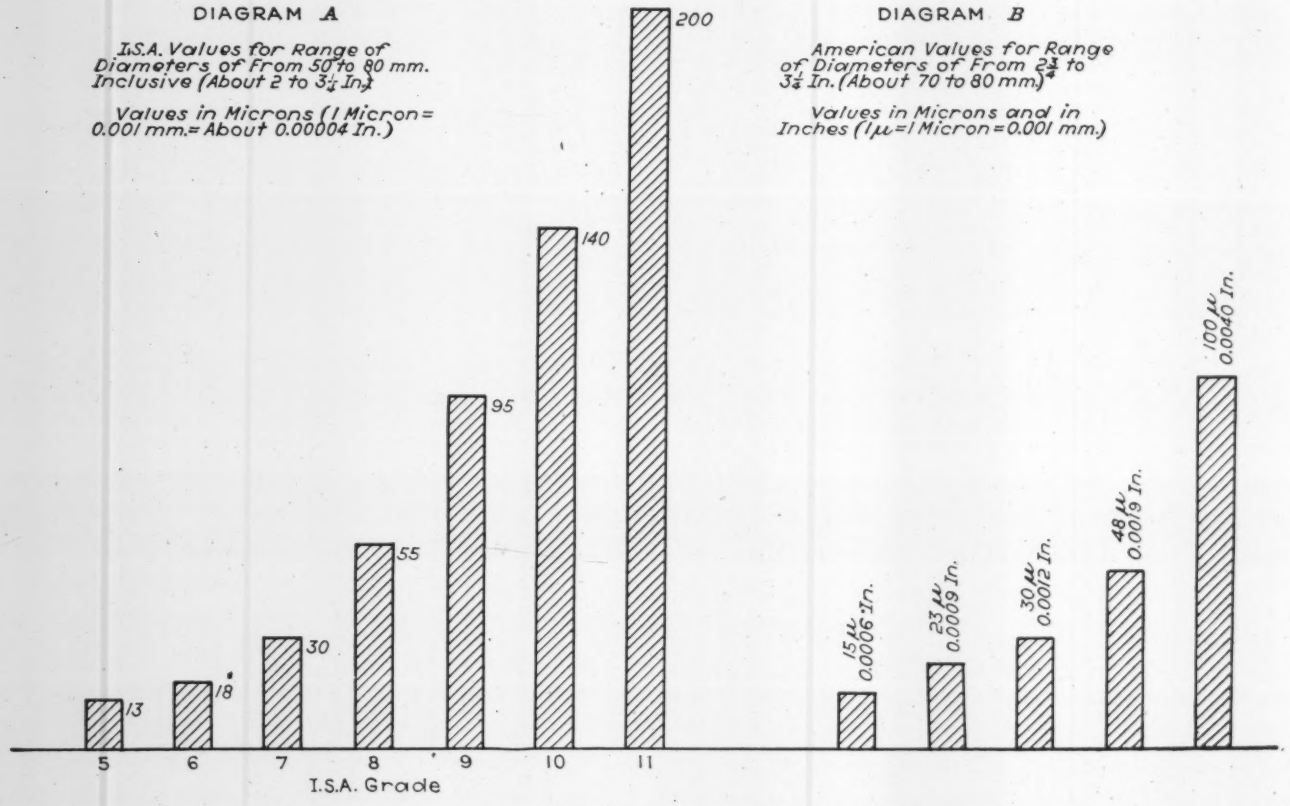

FIG. 4 GRADES OF BASIC HOLES AND SHAFTS IN PROPOSED I.S.A. AND IN AMERICAN SYSTEMS

Thus, plug and snap gages for inspecting product of the precision grade, that is, product with grade-6 holes and grade-5 shafts, see Diagram A, Fig. 4, are to be manufactured with tolerances according to grade 2. Again, the reference gages used for checking these inspection gages must be delivered within tolerances corresponding to grade 1.

TOLERANCES ON GAGES AND THEIR PERMISSIBLE WEAR

Having thus arrived at the question of the gages, we find that in this respect the I.S.A. proposal is a remarkable example of reaching a compromise between two opposite points of view.

In the international subcommittee, the French held the viewpoint, also taken in the American standard, that no variation in the sizes of the gages should be permitted which would lead to the possible acceptance of product exceeding its own manufacturing limits. This principle concerns both the manufacturing limits of the gages themselves and the extent to which they are permitted to wear off in use. According to the French standpoint, the tolerances on the gages and their permissible wear should therefore be specified in the manner shown in Diagram A, Fig. 5.

The German standard, although keeping the manufacturing tolerance on a "go" gage within the tolerance on the product (see Diagram B, Fig. 5), permits the "go" gage to wear a certain amount past the limit of the product which the gage must control. The "not go" gage is given a bilateral tolerance. In the German system, it is therefore theoretically possible for the product to get slightly outside its limits, both on the "go" and the "not go" side. It is claimed that in practice this possibility does not lead to any difficulty whatsoever.

In the I.S.A. proposal, a compromise between these two opposite attitudes has been reached by placing the permissible wear astride on the "go" limit of the product (see Diagram C, Fig. 5), and by giving the "go" gage a bilateral tolerance with regard to the dimension at which wear is supposed to begin. The bilateral tolerance on the "not go" gage was taken over in the I.S.A. proposal from the DIN system on the ground that gages are generally delivered by the manufacturer with a size lying very closely to the average between their two extreme limits.

The tendency to leave to each country as much freedom as possible to work out its own solution of the problem, instead of setting up a rigid standard supposed to be adhered to by all parties concerned,[12] is shown by the fact that the dimensions *a*

than those explicitly specified in the standard are permitted. However, there is a certain natural emphasis on fits that are completely given in these standards and this emphasis will be absent in the I.S.A. system. In this respect, the latter will be similar to the British national standard system.

[12] This is not the purpose of I.S.A. activities, as is explained in more detail later.

and b in Diagram C, Fig. 5, are specified in the I.S.A. proposal as limiting values. That is, each country may specify, in its national standard, a smaller value for a and b if it so desires. In the American standard, the value of a is zero.

In general, it may be said that the importance of the difference in attitude with regard to the above matter will diminish the more the tolerances on gages are reduced through constant improvement in their manufacture, and the more their wear is slowed down through increased hardness of their surfaces, for example, through the use of chromium plating or tungsten-carbide alloys. The latter are said to guarantee the gage a life that is forty times longer than that of a steel gage.

THE I.S.A. PROPOSAL SEEN FROM THE AMERICAN STANDPOINT

With regard to the question whether the American groups are likely to be interested in the I.S.A. work on fits, the following can be said:

Participation in the work so far performed under I.S.A. auspices, in general, not merely on fits, has been restricted to the European countries and Japan. This is due to the fact that the American Standards Association, representing the only "inch" country among the member bodies of the I.S.A., joined the I.S.A. as recently as the fall of 1929 and has not formally appointed any delegates on I.S.A. technical committees as yet.[13] However, informal cooperation between some of the I.S.A. technical committees and American groups has been going on in the form of exchange of information through the channels of the A.S.A.

In so far as the I.S.A. work on fits is concerned, the above conditions have led to the situation that only metric countries happen to have participated in working out the present draft of an I.S.A. system. At first sight it might appear that agreement between inch and metric countries on standard fits is out of the question in principle, for the simple reason that there is a difference in their most commonly used nominal diameters. In practical language, the question is likely to be raised in some quarters: "Why try to agree on allowances and tolerances for fits—measured in thousandths or even ten-thousandths of an inch—when the nominal size of a 1-inch hole or shaft differs from the nearest round millimeter size (25 mm.) by as much as about $^1/_{64}$ in., that is, by an amount of a different order of magnitude than the usual allowances and tolerances?"

In this respect it should be kept in mind that there are numerous cases where it has been proved to be worth while—for the sake of international interchangeability of parts—to agree on an odd nominal size, be it in inches or in millimeters. One case in point is that of ball bearings whose main dimensions—bore, outside diameter, and width—have been laid down in a truly international standard in round millimeter sizes and their equivalent odd-inch sizes. Another case is that of Morse tapers whose original inch dimensions have been taken over and converted into odd-millimeter sizes by several metric countries as a national standard. It seems quite plausible to assume that the number of cases of this kind will increase considerably in the next ten years.

Whenever international agreement on uniform nominal dimensions is reached, it is obviously essential that the fits between the parts in question should also be unified in the several countries. This condition has already been reached with regard to the tolerances on the most current types of ball bearings. It is important to note, in this respect, that such agreement can be reached without either of the parties giving up its preferred practice of working to the inch or the metric system.

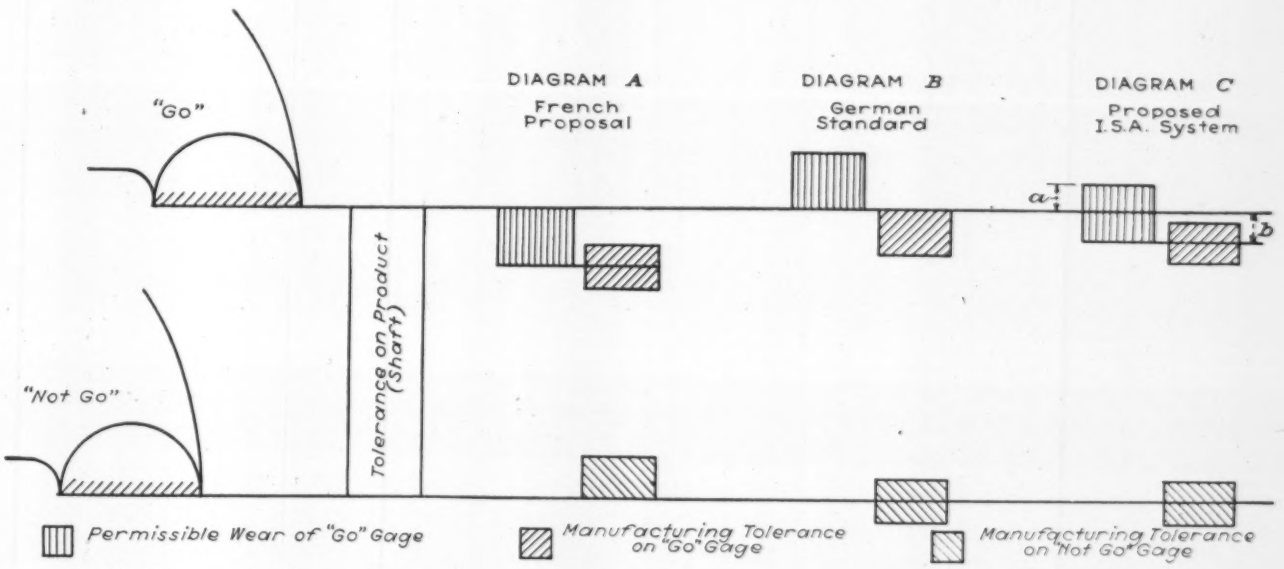

FIG. 5 MANUFACTURING TOLERANCES ON GAGES AND THEIR PERMISSIBLE WEAR

SUBDIVISION OF RANGE OF NOMINAL DIAMETERS

The proposed I.S.A. fits so far worked out apply to nominal diameters of from 3 to 180 mm., inclusive. Work on fits for larger diameters will be started later. The subdivision of the range 3 to 180 mm. into subranges for each of which the allowance and the tolerances on the mating parts remain constant, is as follows:

From	3	to	6	mm., inclusive
Above	6	to	10	mm., inclusive
Above	10	to	18	mm., inclusive
Above	18	to	30	mm., inclusive
Above	30	to	50	mm., inclusive
Above	50	to	80	mm., inclusive
Above	80	to	120	mm., inclusive
Above	120	to	180	mm., inclusive

These subranges would be approximated in the inch system, closely enough for practical purposes, by the following:

[13] The other "inch" countries having a national standardizing body, Great Britain, Canada, and Australia, have not yet joined the I.S.A.

From	1/8	to	1/4	in., inclusive
Above	1/4	to	13/32	in., inclusive
Above	13/32	to	23/32	in., inclusive
Above	23/32	to	1 3/16	in., inclusive
Above	1 3/16	to	2	in., inclusive
Above	2	to	3 1/8	in., inclusive
Above	3 1/8	to	4 3/4	in., inclusive
Above	4 3/4	to	7 1/8	in., inclusive

There would still remain a very slight difference between the separating values in the inch and in the metric series of subranges. For example, 1 3/16 in. converted into millimeters gives 30.16 mm., instead of 30 mm. However, a check on the nominal diameters most commonly used in both systems will prove that all of these fall in corresponding subranges. This is more important than having round numbers for the separating values. Even though a value like 4 3/4 in. may seem somewhat artificial as a separating figure—5 in. would seem more natural, in the inch system—it will not cause any difficulty, as everybody will know at once whether a particular diameter in which he is interested is smaller or larger than this value.

The above equivalent-inch series of subranges is mentioned here simply as a possible solution, but not necessarily as the best one, from the American standpoint. It may very well be that upon closer consideration we might prefer a somewhat different subdivision of the total range of nominal diameters. Such points might be discussed with the delegates of the other countries. The only thing we have tried to prove here is the fact that, in principle, agreement on the subdivision of the range of diameters does not seem to present special difficulties.

Numerical Values of Allowances and Tolerances

The extensive comparative study of the different national systems made by the German national body in its capacity of secretariat of the I.S.A. work on fits, has shown that fits of a similar character have been standardized in the several countries with allowances and tolerances whose numerical values very often lie very close together and sometimes even are perfectly identical.

This is not surprising. Modern methods of machining parts are becoming more and more universal and manufacturing practice in all industrial countries must necessarily present the same problems to be solved in a similar manner. There are, of course, such variations as are due, for example, to difference in volume of production per unit of time, but, as a whole, the requirements of establishing a fit between parts expected to behave, when assembled, in a certain manner, under identical conditions, may be said in principle to be "cosmopolitan."

It seems, therefore, that international agreement even on those details of a system of fits that concern directly the workshop, must not be so very difficult to reach. Again, the variety of fits provided by the proposed system will guarantee sufficient freedom of choice to all users of fits, while, on the other hand, the fact that cooperation has been effected will prevent unessential variations in practice from excluding interchangeability where it might be had. For example, in a specific case, a tolerance on a part of 0.005 in. may be just as good as one of 0.006 in. However, so long as no definite agreement on the exclusive use of either figure has been reached, mutual acceptance of parts will be impossible and needless diversity in practice will continue to exist.

Tolerances on Gages and Their Permissible Wear

Referring to what has been said about tolerances on gages and their permissible wear, it seems that the only point that might call for further discussion, on the American side, is the bilateral tolerance on the "not go" gage.

Conclusion

Taking all of the above considerations together, the writer suggests the following:

1 The work performed under the auspices of the International Standards Association on the subject of fits between cylindrical parts should be recommended to the attention of the American groups interested in this matter.

2 It would be desirable for the American groups to participate in this I.S.A. work in some manner, especially as the American Standards Association, which has approved a Tentative American Standard on Tolerances, Allowances, and Gages for Metal Fits, is a member body of the I.S.A.

3 Consideration and study of the I.S.A. proposal might advantageously be combined with a review of the above-mentioned Tentative American Standard for the purpose of ascertaining whether this standard, approved in 1925, requires any revision. Evidently, any revision of the national standard desired by American industry should preferably be dealt with at the same time as the question if, and, if so, to what extent, American industry should participate in developing a standard which is internationally acceptable.

It cannot be strongly enough emphasized that American participation in this or any other I.S.A. project does not commit the American groups concerned to the formal adoption of the system ultimately elaborated. It has been definitely understood, since the inception of the I.S.A., that this body would not set up international standards. This would not be in accordance with the basic principle adopted by the majority of national standardizing bodies, according to which industrial standardization must be carried out by national industry itself and its results adopted voluntarily by the latter, but not enforced by any agency. If this principle of voluntary adoption holds true nationally, it must, of course, also apply internationally.

However, without a body like the I.S.A., whose task it is to bring those interested around the table to discuss their common problems, international agreement on standards would have remained latent—for sheer lack of opportunity to discuss matters—for a long time, even in cases where it now already has been reached or is well on its way toward accomplishment.

New Code for Grinding Wheels

A REVISED edition of the American Standard for the Use, Care, and Protection of Abrasive Wheels has just been approved by the Standards Council of the American Standards Association.

In 1926, the maximum speed for the vast majority of grinding wheels was 6000 to 6500 peripheral feet per minute. The present code provides for maximum speeds varying from 4500 to 16,000 ft. per min., these higher speeds having been made possible by the use of synthetic resin and rubber-bonded wheels.

According to the introduction to the code, "The importance of proper wheels, correct mounting, suitable machines, careful operation and proper speed are recognized as means of preventing wheel breakage, but as all of these things are dependent on human control, it is considered essential that some form of mechanical guard be employed at all times." The revised code includes requirements for types of protection devices; storage and inspection of wheels; general machine requirements; protection hoods; work rests; protection for cup, cylinder, and sectional ring wheels; flanges; mounting; speed; operating rules and general data. It applies to abrasive wheels three in. and larger in diameter, operating at speeds exceeding 2000 surface feet per minute.

The Strength of Welded Bull Plugs[1]

Results of an Investigation of Two Types of Welded Pressure-Vessel Heads

By CORNELIUS L. HUGHES,[2] SAN FRANCISCO, CALIF.

TWO TYPES of welded heads are widely used in closing the ends of small pressure vessels made from pipe and in plugging the ends of pressure pipe lines. These two types are the orange-peel head or the orange-peel bull plug, and the bonnet head or the blunt bull plug. The orange-peel head is made by cutting an uneven number of wedge-shaped pieces from the end of the pipe, beveling and bending inward the wedges remaining on the end of the pipe until their edges touch one another, and welding the beveled edges together. The bonnet head is made by cutting two diametrally opposite, large, V-shaped pieces from the end of the pipe, and, from the perimeter of another pipe of the same size, cutting out a section which is fitted to the edges of the V-shaped gaps. The edges of both sections then are beveled and welded together. Fig. 1 shows both head types.

Although both types of head are frequently used, little information is available on the strength of either type. This article will deal with a series of tests made on six heads of each type in which the ultimate strength and the elastic curves of each head were sought. The heads were expanded and ruptured by hydrostatic pressure, and before rupture the head deformation was measured volumetrically.

A pair of heads of each type was made in three different internal diameters of seamless steel pipe; the internal pipe diameters being, respectively, $3^1/_2$ in., 5 in., and 8 in. In making each test head a length of pipe about 14 in. long was cut off, and, with the exception of an inch at one end, the pipe wall was turned to a uniform thickness of about $^1/_8$ in. The end of the turned section was cut, beveled, shaped, and welded to form the head, while the other end of the pipe section was threaded. The threaded end was screwed into a steel base which not only served to close the open end of the test head, but also provided material to which the pressure line was connected. The turned pipe wall between the welded head and the base prevented the rigid base from influencing the deformation of the head, and provided gripping surface for the wrench used in screwing the test head into the base.

Before cutting the pipe, a templet was drawn out and pasted to the turned end of the pipe. The metal outside the templet was cut away with a hacksaw or otherwise, but not with an acetylene torch, to the outlines of the templet. The edges of the outlines were then beveled. The bonnet heads required no working of the metal after the pipe had been cut to the templet outlines. The wedges of the orange-peel heads were heated and bent inward over cast-iron hemispheres, the radii of which were the same as the respective internal pipe radii. Each 5- and 8-in. orange-peel head consisted of seven wedges or peels and seven welds meeting at the top of the head, and each $3^1/_2$-in. orange-peel-head consisted of five peels and five welds. The external appearance of four of the test heads may be seen in Fig. 1. In Fig. 1 *a* and *c* are 5-in. diameter heads, and *b* and *d* are 8-in. diameter heads. Although the photographs were taken after the heads had been ruptured, very little difference could be seen between the heads before and after rupture, except in the instances where the seams actually parted. The arrows on the heads point to the locations of the ruptures.

The quality of the welding was probably as good as, but no better than, the average commercial work. In several instances the heads ruptured in visibly weak sections in the welding. Among the welding weaknesses which could be seen on the surface were small oxide inclusions in the seams and low spots where no excess deposited weld material had been built up over the seam and the thickness of the weld was equal to or less than that of the pipe metal. The welding rod used was a low-carbon steel rod containing, on analysis, from 0.05 to 0.08 per cent carbon.

The Test Apparatus

The pressure was obtained from and measured by a pressure-gage tester. Connecting the gage tester with the steel base was a length of small-diameter copper tubing with its necessary brass couplings. In the tests the welded head was screwed into the base and filled with water, and the gage-tester pressure chamber and the copper pressure line were filled with heavy oil. By forcing a plunger into the gage-tester pressure chamber some oil was displaced from the chamber into the line, which in turn drove oil from the line into the test head, causing it to expand.

The elastic curves of each head were obtained by measuring the volume of water displaced from a container surrounding the expanding head. The apparatus used to indicate the distortion of the head, shown in Fig. 2, consisted of a closed, water-filled, cylindrical, metal container which fitted around the head and rested on lugs soldered to the outside of the body wall beneath the welded head. A calibrated glass capillary tube issued from the top of the container, and into this tube passed the water displaced by the expanding head. A capillary tube of different diameter was used with each diameter of test head. A scale, held close to the capillary tube, measured the height of the water in the tube.

It was necessary that the joint between the bottom of the container and the outside perimeter of the test-head body be watertight and at the same time offer no resistance to the free expansion of the body of the test head. The bottom of the container consisted of two steel rings; one a solid ring resting on three lugs soldered to the perimeter of the pipe wall and of inside diameter just great enough to allow it to slip over the welded head; the second a split ring, that is, a ring cut in half, fastened to the top of the solid ring and of inside diameter about 0.1 in. greater than that of the test head. Around the perimeter of the test-head body between the welded head and the lugs were three turns of friction tape. Between the friction tape and the upper surface of the split ring, a watertight fillet was made completely around the test-head body, which prevented the escape of water from the container while the head was expanding or contracting. This fillet, an enlarged section of which is shown in the lower

[1] Abstracted from a thesis entitled "An Investigation of Two Types of Pressure-Vessel Heads," presented to Stanford University, March, 1930.

[2] Engineering Department, Standard Oil Co. Mr. Hughes received his A.B. in Engineering from Stanford University in 1927, and this year his M.E. degree.

right-hand corner of Fig. 2, was composed of a layer of gasket cement over which was spread a layer of thick waterproof grease. Some of the gasket cement was forced into the slit between the tape and the inside surface of the split ring. The cement, if it were not allowed to dry out, remained in a plastic condition. The thick waterproof grease not only helped to make the joint watertight, but also played a major part in supporting the water in the container above the joint.

In preparing for each test, the test head screwed into the base was filled with water, and the pressure line from the gage tester was connected to the steel base and filled with oil, care being taken to eliminate all the air from the pressure system. The container was then placed around the head and filled with water, the water level in the capillary tube being brought to such a height as to be indicated on the scale beside the tube. The attempt was made to expel all air from the container; however this was impossible, and the very small volume remaining entrapped in the container during each test had considerable effect on the data obtained, as will be explained.

FIG. 1 FOUR OF THE WELDED HEADS TESTED

ELASTIC CURVES

The elastic curves of each head were obtained by first increasing the pressure within the head by equal increments to well over the first yield point of the head material, and noting the height of the water column at the end of each successive pressure increase. The yield point was disclosed by the sudden increase in the increments of water column height, which previously had been of equal magnitude corresponding to equal pressure increments, as the yield point was passed. After passing the yield point the pressure was decreased toward zero in equal steps, and data for the falling pressure curve were taken. Two typical curve groups are shown in Figs. 3 and 4. In Fig. 3 are the curves obtained from the orange-peel head in Fig. 1*a*, and in Fig. 4 are those obtained from the bonnet head in Fig. 1*c*. In both curve groups the increasing-pressure curves show that the expansion of the head was approximately proportional to the increase in pressure up to the yield points. Beyond the yield points the slopes of the curves noticeably increase, and the increase in volume no longer bears a direct proportional relationship to the increase in pressure. The decreasing-pressure curves are more erratic than the increasing-pressure curves, but this is due to certain inadequacies of the displacement apparatus, as will be explained. Among the discrepancies to be noted in the curves are the failure of the indicated volume to decrease immediately on the

TABLE 1 TEST RESULTS

Internal diameter, in.	Wall thickness, in.	First yield point: Internal pressure, lb. per sq. in.	First yield point: Circumferential stress, lb. per sq. in.	Rupture: Internal pressure, lb. per sq. in.	Rupture: Circumferential stress, lb. per sq. in.	Location of rupture	External appearance of weld at rupture
				Orange-Peel Heads			
3.50	0.125	2000	28,000	2975	42,000	In middle of seam near top of head	No excess welding material built up over seam at point of rupture
3.50	0.109	Not taken		3400	55,100	In middle of seam near bottom of head	No weakness could be seen
5.00	0.135	2200	40,700	2870	53,100	Entire seam split at side of weld	No weakness could be seen
5.00	0.127	2200	43,300	3150	62,000	At side of seam near top of head	No weakness could be seen
8.00	0.168	1100	26,200	2300	54,800	Two ruptures. One on side, one in middle of same seam	Both occurred where weld was thinner than pipe material, for no excess welding material was built up over weld
8.00	0.172	1500	34,900	2400	55,800	Entire seam split at side of weld	No weakness could be seen
				Bonnet Heads			
3.50	0.130	1900	25,600	3000	40,400	In middle of seam near top of head	Oxidized inclusions in seam
3.50	0.131	1600	21,400	2100	28,000	In middle of seam toward bottom of head	Metal slightly burnt
5.00	0.128	550	10,700	1420	27,800	Upper edge of seam at top of head	No weakness could be seen
5.00	0.127	600	11,800	1510	29,800	In middle of seam near top of head	Oxidized inclusions in seam
8.00	0.175	400	9,150	1280	29,200	Upper edge of seam at top of head	No weakness could be seen
8.00	0.162	300	7,410	900	22,200	Crack at edge of seam near top of head	No weakness could be seen

Seamless Steel Tubing and Casing

Tension tests of	$3\frac{1}{2}$-in. tubing	5-in. tubing	8-in. casing
Elastic limit, lb. per sq. in.	60,000	60,000	45,000
Ultimate strength, lb. per sq. in.	95,000	85,000	75,000

initial decrease of the pressure, the extremely large permanent set indicated at zero pressure after the pressure had been dropped from one or more yield points, and, in the case of the curves of the orange-peel head shown in Fig. 3, the fact that the indicated displaced volume was less when the pressure was returned to zero the first time than it was at the beginning of the test. These discrepancies were due to the expansion of the fillet of cement and grease used to prevent the escape of water from the container.

As the head expanded the cement and grease fillet expanded with it, and some of the cement was driven from the slit between the friction tape and the split ring. When the pressure inside the head was decreased, the head contracted, but, since the fillet was not in a state of tension and possessed some rigidity, the pressure of the water above did not cause it to contract immediately to the same extent the head itself contracted. This accounts for the slight postponement in the drop of the indicated displaced volume. When the pressure was returned to zero the fillet did not resume its original position around the test-head body, but remained slightly enlarged. The test head expanding against the cement in the slit between the friction tape and the split ring either forced the cement up into the container, which would have increased the size of the fillet, or it forced the cement down toward the bottom of the rings. In the majority of the tests some of the cement from the slit moved up into the container and added its volume to that of the fillet. At zero pressure this additional volume and the enlargement of the fillet produced an indicated volumetric set greater than that corresponding to the permanent set of the head. Since the enlargement of the fillet and the permanent set of the head could not be separated one from the other, no information could be obtained on the permanent sets acquired by the heads tested. On the other hand, in the test whose curves are shown in Fig. 4, most of the cement in the slit moved down when the pressure was increasing, but it was not forced back into place when the head contracted, and the inner base of the fillet was left unsupported. Some of the cement from the fillet above then moved down into the slit and assisted the fillet in supporting the weight of the water above. Since this movement removed some of the cement from inside the container, the volume of water in the capillary tube decreased an equal amount. In

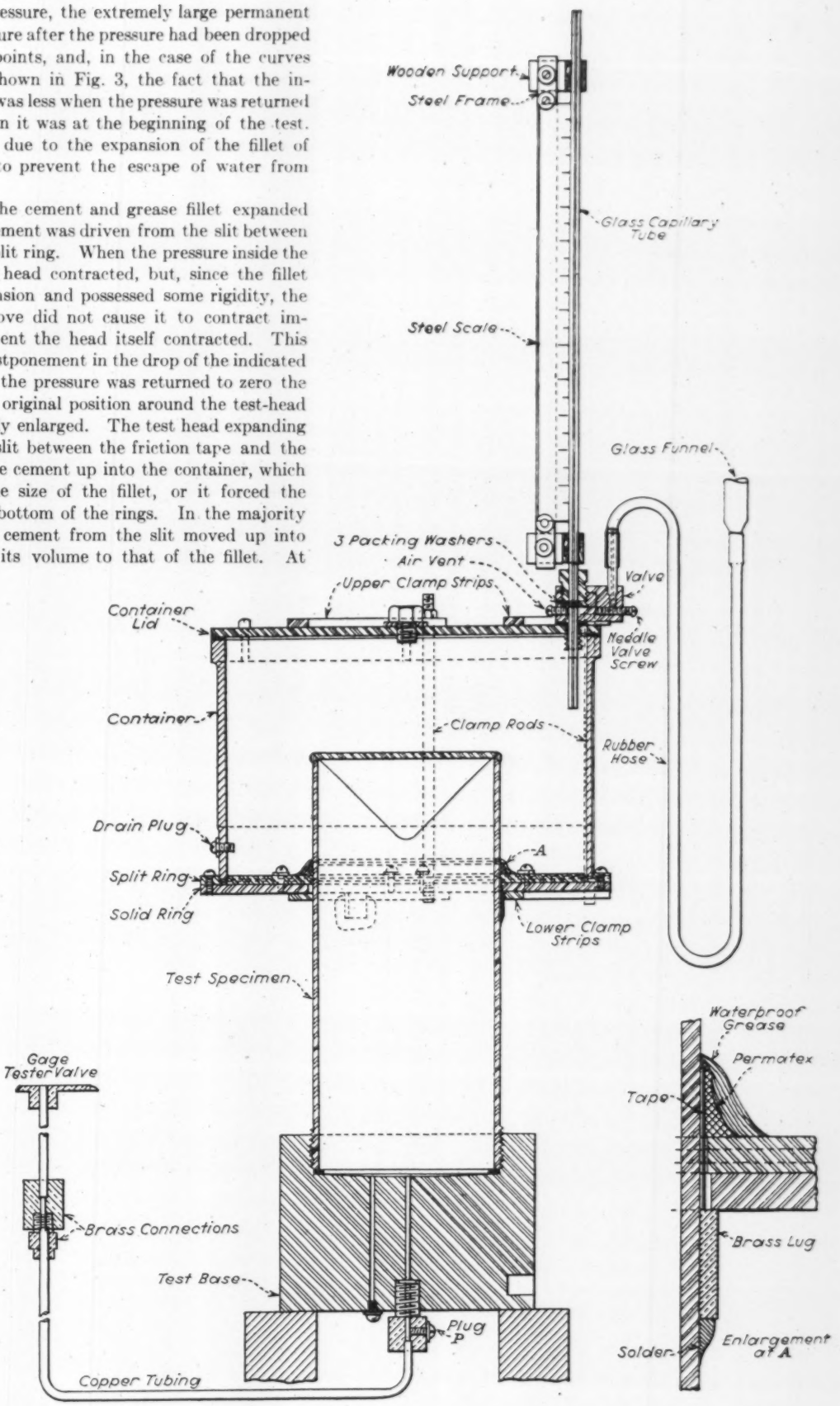

FIG. 2 DIAGRAM OF TEST APPARATUS

Fig. 3 the dropping of the first decreasing-pressure curve to indicated displaced volume values less than the indicated volume at the start of the test, was due to the fact that the cement which had passed from the fillet into the slit had a greater effect on the height of the water column than had the combined effects of the enlargement of the fillet and the permanent set of the head.

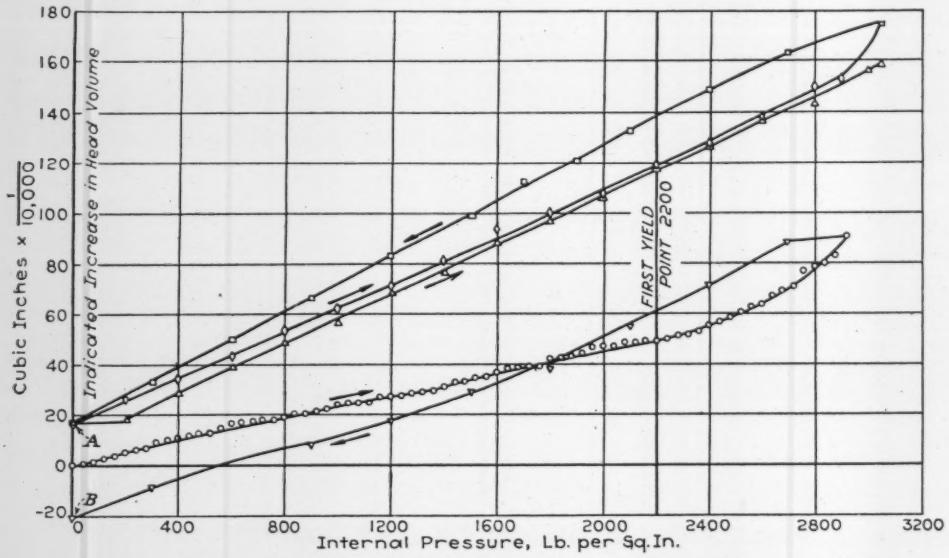

FIG. 3 INDICATED HEAD DISTORTION OF ORANGE-PEEL HEAD

NOTE: Break in experimental continuity from point B to point A. The height of the water column was raised by hand.

(Bursting pressure, 3100 lb. per sq. in. Mean head and wall thickness, 0.135 in. Mean internal tube diameter, 5 in. Material, cold-drawn seamless steel tubing.)

As was mentioned before, it was impossible to expel all the air from the displacement container, and the small volume remaining entrapped in the container altered the shapes of the curves, for as the water-column height increased in the capillary tube, the volume occupied by the air was decreased. The effect was to give an indicated volume less than the true displaced volume. The error in the indicated volume was proportional to the amount of air in the container and to the height of the water column. Since it was impossible to determine the amount of this air, correction for it could not be made.

The important curve in each group was the initial increasing-pressure curve from which the first yield point was determined. Neither the fillet nor the air in the container had any influence on the position of the yield point in this initial curve. The error due to the air depended on the height of the water column, which in turn was dependent on the amount of head expansion. The error due to the fillet within the container was small, for as the body of the test head expanded the fillet expanded with it. However, the fillet may have been slightly enlarged by the cement forced from the slit; yet the amount of cement in the slit was small, and its movement was caused by the expansion of the test-head body wall. The fillet or the entrapped air could not have caused the increase in the slope of the curve which occurs beyond the yield point. Because of the errors introduced by the apparatus, the curves are entirely qualitative, but the yield-point pressures are fairly reliable. The internal pressures corresponding to the indicated yield points of the heads tested will be found in the test results in Table 1.

RUPTURE TESTS

After sufficient data had been obtained on the elastic behavior of each head, the displacement container was removed, and the internal pressure was slowly increased until a rupture appeared in the head. In the table the internal pressures at the yield point and at rupture, as well as the corresponding circumferential stresses in the body wall at these pressures, are given for each of the twelve heads tested.

In neither the orange-peel heads nor the bonnet heads did the circumferential stresses corresponding to the first yield points approach a consistent average value. Corresponding to the rupture pressure the average circumferential stress was about 55,000 lb. per sq. in. for the orange-peel heads, and about 28,000 lb. per sq. in. for the bonnet heads. In each type of head, one head burst at a stress considerably below these average stress values, and in both cases the respective average stress was about 1.3 times the actual bursting stress. In each orange-peel head the yield-point stress was at least 48 per cent of the bursting stress, while of each bonnet head the yield-point stress was at least 33 per cent in the bursting stress.

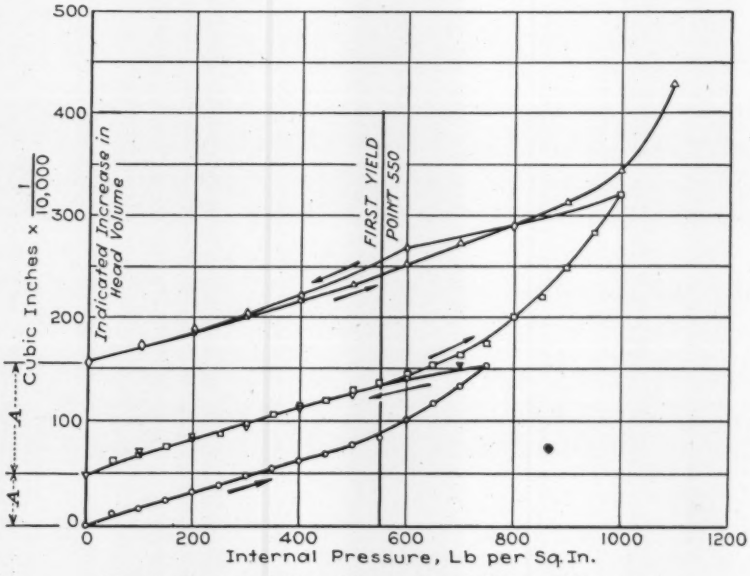

FIG. 4 INDICATED HEAD DISTORTION OF BONNET HEAD

NOTE: Distance A should not be taken as permanent set.

(Bursting pressure, 1450 lb. per sq. in. Mean head and wall thickness, 0.128 in. Mean internal tube diameter, 5 in. Material, cold-drawn seamless steel tubing.)

The orange-peel head rupture appeared at no particular section of the head, for the head was spherical, and no stress con-

(Continued on page 939)

Combustion Radiation and the Planck Quantum Theory[1]

By WALTER J. WOHLENBERG,[2] NEW HAVEN, CONN.

In the September issue of Mechanical Engineering, the first instalment of Professor Wohlenberg's paper including Part I—The Problem and General Principles, and Part II—Radiation Energy Distribution as judged from the End States of the Reaction, was Published. The present instalment comprises Part III. Parts IV, V, and VI will appear in subsequent issues.

In the parts of this paper published last month the author explains briefly the Planck quantum theory and shows that the quantum of energy is fixed by the Planck constant and the frequency of the radiation wave. While many applications of the theory have been made by scientists, neither scientist nor engineer, in so far as the author is aware, has ever applied it to evaluate the particular radiation that is emitted from atom groups entering to form product molecules during the combustion reaction as it occurs, for instance, in the boiler furnace. Without resorting to mathematical analyses unfamiliar to the average engineer, but using the method of statistical mechanics, and the second law of thermodynamics, the author shows that the frequencies of the quanta emitted from the reacting groups of atoms must, for all but a negligible part of the total radiated energy, fall within the infra-red or heat-wave range.

III—The Laws of Energy Distribution and the Distribution of Energy of Combustion Radiation

Consider N particles, such as gas molecules, all of the same type and having any number of degrees of freedom. Since both the number of the particles and their type are fixed, they may not be undergoing a chemical change. Their chemical constitution is thus fixed and therefore the energy which might be released in chemical reaction is not one of the components that enter into the circulation of the total energy involved. This is confined to the total thermal energy of the system.

Consider also, that a state of equilibrium exists which, from our present point of view, corresponds to the most probable distribution of the total thermal energy E among the N particles, each of which has any energy u_ϵ. For this energy state it is found from statistical mechanics that

$$P_\epsilon = \alpha e^{-\beta u_\epsilon} \quad \ldots\ldots\ldots\ldots\ldots\ldots [2]$$

in which P_ϵ represents the probability that any one of the particles will have the energy u_ϵ. From the way in which β is introduced in this equation it is evident that it must be related in some way to a coefficient of facility for transferring the energy u_ϵ to the ϵth particle. The constant α depends, among other things, on the type of particle under consideration and therefore on the nature of the substance with which the energy equilibrium is associated.

Since the total thermal energy involved is concerned here, latent heats of fusion or vaporization may form a part of it. Latent heat is a macroscopic indication of the potential energy associated with the mean microscopic position of the particles, rather than their relative motions, and the status of such energy components with respect to an energy circulation which results in the equilibrium distribution of the energy must naturally be examined.

In the final analysis, a net exchange of energy between particles may occur in only two ways. One of these, radiation, involves the internal atomic energy of the atoms or molecules between which the exchange occurs. The internal atomic energy has its potential fixed by dimensions of the quantum levels occupied by whatever the term "orbital electrons" implies. It is exchanged between atoms, as before noted, in the form of quanta. During the transfer there is a compensating displacement of electrons between the so-called quantum orbits. For the present, however, it will be assumed that, in a state of thermal equilibrium, the quantum states of all but a negligibly small number of the involved particles are either fixed at, or are oscillating within a small range of, the mean quantum levels. This means that, under the present assumption, only a negligibly small amount of the net energy in circulation is due to radiational influences. Any appreciable transfers of energy, therefore, between any of the N molecules confined within a cavity can occur only through the agency of the motions of the microscopic particles which bring them within each other's spheres of influence, because mean energy of position obviously can not, as such, be directly transferred from one group of particles to another.

It follows that the facility for distributing whatever total thermal energy is present is proportional to the part of this energy which is in the form of the kinetic energy of the microscopic particles. Macroscopically, the absolute temperature indicates the mean kinetic energy of the microscopic particles, and, therefore, it is not surprising to find that

$$\beta = 1/kT$$

where k is the gas constant per molecule per degree. The product kT is the kinetic energy associated with one degree of freedom, i.e., along one of the three coordinate axes, if the motion considered is one of translation. The form of the result for β and the manner of its inclusion in Equation [2] shows that the coefficient of the probability of the energy u_ϵ per particle is $1/\beta$. This, then, is the coefficient of the facility of the distribution of the energy.

Radiation plays a part in the process to the extent to which it tends, directly or indirectly, to even out differences in the kinetic energy and potential energy of mean position of the involved particles. However, the distribution of energy by quanta proceeds with the velocity of light across space and this is not true of the adjustments made through the agency of the kinetic energy of the particles. At any instant, therefore, all adjustments of the energy distribution which could have been made by quanta will have occurred, leaving, so to speak, residual differences of thermal potential energy of microscopic position and kinetic energy hanging in space-time behind them for later distribution in the energy-equalization process of the system. Since, however, the conditions leading to such thermal adjustments may in themselves disturb the quantum states,

[1] Continued from September issue.

[2] Sterling Professor of Mechanical Engineering, Yale University. Mem. A.S.M.E.

but only for a small part of the total energy if the state is one of thermal equilibrium, radiation is unquestionably occurring during such adjustments, partly as the result of them and in conjunction with them. Since this process, which is superimposed on the energy equalization through the agency of kinetic energy, has been neglected, the facility of the distribution of the energy is somewhat greater than we shall now find, and possible variations in the energy per molecule are therefore somewhat less than we shall find. Later, this influence on the energy distribution will be discussed in greater detail.

DISTRIBUTION EQUATIONS FOR THERMAL EQUILIBRIUM

In order to find the part E_e of the total thermal energy E which may be associated with the particles having any particular

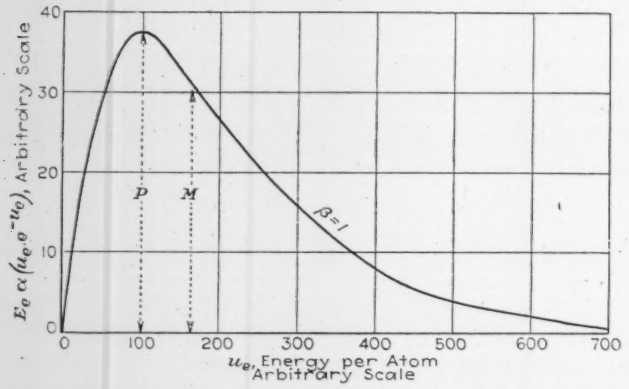

FIG. 2 CURVE OF RELATION OF E_e AND u_e, SHOWING THAT MOST PROBABLE VALUE OF u_e IS LESS THAN ITS MEAN VALUE

energy u_e per particle, it is necessary to determine the number N_e of these particles. This follows from the relation:

$$P_e = N_e/N$$

whence

$$E_e = N_e u_e = NP_e u_e$$

and

$$E_e = \alpha N\{u_e e^{-\beta u_e}\}$$

The last equation may be stated in the form

$$E_e = \frac{\alpha N}{\beta}\left\{\beta u_e e^{-\beta u_e}\right\} \quad \ldots\ldots\ldots\ldots [3]$$

For a specified energy freedom, involving a given total number N of the particles, the factor $\alpha N/\beta$ is, of course, a constant. The value of E_e is thus proportional to the expression within the brackets. If this is evaluated in terms of units βu_e, it is apparent that whatever the value of β, only a single curve results, but the scale of the curve is determined by the value of the constant $\alpha N/\beta$. The shape of the curve and its relative proportions are, however, uniquely determined by the expression within the brackets. Thus for the present, the value of unity may be assigned to β and also to the constant $\alpha N/\beta$. Such a curve is shown in Fig. 2, from which it is evident that, whatever the facility for transferring the energy from particle to particle, the energy E_e associated with varying values of u_e per particle rises from zero at u_e equals zero to a maximum value as u_e increases up to a certain point. Beyond this the energy E_e falls off rapidly as the energy u_e per particle increases still more. The ordinate P is shown at the most probable value u_e, and the ordinate M at the mean value of u_e. Thus it is apparent that the most probable value of the energy u_e is somewhat less than its mean value.

In order to determine what fraction of the total energy E may be associated with all particles having a certain energy equal to or less than u_e, and hence what part of E may be present for energies per particle greater than this value, the following integration is performed.

$$\int_0^{u_e} E_e du_e = \frac{\alpha N}{\beta}\int_0^{u_e} \beta u_e e^{-\beta u_e} du_e$$

This reduces to

$$\int_0^{u_e} E_e du_e = \frac{\alpha N}{\beta^2}\left\{1 - (\beta u_e e^{-\beta u_e} + e^{-\beta u_e})\right\}$$

For a given specification as to the equilibrium, $\alpha N/\beta^2$ is again a constant, whence $\int_0^{u_e} E_e du_e$ is proportional to the expression within the brackets.

Let

$$\beta u_e e^{-\beta u_e} + e^{-\beta u_e} = F \quad \ldots\ldots\ldots\ldots [4]$$

Since $(1 - F)$ is a fraction representing the part of the total energy E which is associated with all particles having energy equal to or less than u_e per particle, then F represents the fraction of the total energy E which is present for particles having an energy greater than u_e per particle.

This is plotted in Fig. 3, again with β equal to unity. The mean value of the energy u_e per particle falls under the ordinate M at u_e equals 162 units. The rapid decrease of the fraction F with increasing u_e is shown and the following values may be taken from the curve.

For mean value of u_e	$= 162$	$F = 0.50$
For two times mean value, u_e	$= 324$	$F = 0.17$
For three times mean value, u_e	$= 486$	$F = 0.04$
For four times mean value, u_e	$= 648$	$F = 0.01$

Thus it is obvious that in an equilibrium state not more than one per cent of the total energy E may be associated with par-

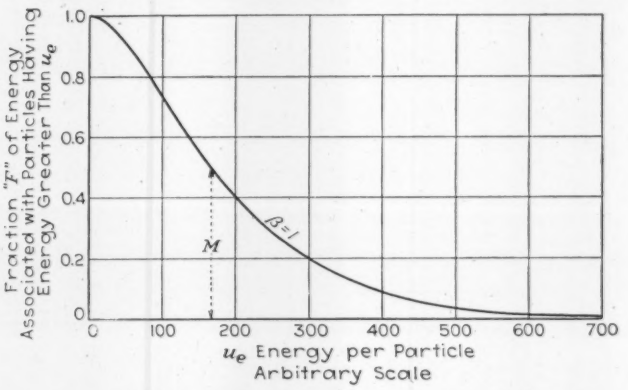

FIG. 3 ENERGY DISTRIBUTION IN EQUILIBRIUM FOR ANY GROUP OF IDENTICAL PARTICLES

ticles having an energy greater than four times that of the mean energy per particle.

Lest some one draw the hasty conclusion from the foregoing figures that by taking very small samples from different parts of the mass of the substance which is in equilibrium a quantitative experimental check on these figures might be obtained, it should be said that no matter how minute the sample, if it is still large enough for experimental methods, it would contain billions of particles and therefore is still an exact representation of the macroscopic average of the whole. But within the small sample the distribution is such that these figures for F are representative.

The ways in which the energy release quota Δe may vary may now be investigated in greater detail.

THE ENERGY RELEASE QUOTA Δe

The total energy e_A of a group of atoms which enter to form a product molecule may be considered as composed of two parts, as follows:

$$e_A = e_T + e_C \quad [5]$$

where e_T represents the energy due to the thermal state above some reference plane, and e_C that which may be released in this thermal state when the atom group undergoes chemical reaction. An instant after the reaction is complete, e_C has been completely converted to thermal energy, whence, for these conditions, whatever energy e_B is left in the product molecule is thermal energy. Later, if e_B has been reduced to e_T, all of the chemical energy e_C will not only have been released, but it will have been discharged from the atom group.

In general, then,

$$\begin{aligned} \Delta e &= e_A - e_B \\ &= e_T + e_C - e_B \\ &= (e_T - e_B) + e_C \quad [6] \end{aligned}$$

Thus the released energy falls short of the chemical energy e_C when the thermal energy of the product molecule is greater than that of the atom group at the instant the reaction begins. In a constant-temperature reaction, then, the term $(e_T - e_B)$ contains any differences in thermal capacities existing for this temperature between the initial and final state of the atom group. In special cases this may be present in the form of latent heat.

Assume that the conditions of chemical equilibrium are such that when the reaction once starts it progresses to completion. In this case no appreciable amount of the energy released in combustion may be the result of a partially burned atom group. All but an infinitesimal amount of the total energy ΔE released has been contributed in quotas released from groups of atoms entering to form the product molecules; and in each individual case, one initial group has exactly the same chemical constitution as every other initial group and each individual final group has exactly the same chemical constitution as every other final group. To this extent, then, this part of the process has not only macroscopic but also microscopic uniformity. Furthermore, none of the nuclei of the atoms entering the process have been changed during the reaction, and for every product molecule the same total number of orbital electrons exist before and after the reaction.

Assume that for every atom entering, the normal quantum state (state of lowest energy and hence most probable state) had existed before the reaction, and that after the reaction every product molecule is reduced to its normal quantum state. Under these conditions it is quite obvious that microscopic uniformity is complete for conditions before the reaction began and again for the conditions after the reaction ceases. Thus by definition the total chemical energy per product molecule must necessarily be of exactly the same magnitude for every like atom group which enters to form like product molecules. By definition the state of each of the entering atom groups has been fixed so that it is the same for all. Likewise the state of the product molecules has been fixed so that it is the same for all. The difference in states obviously fixes the differences in energy and hence fixes the energy quota e_C regardless of whether it is of microscopic or any other dimensions. It follows that the release energy quota per molecule

$$\Delta e = (e_T - e_B) + e_C$$

can in no case differ in magnitude from each other by amounts which are larger than are the corresponding differences for the term $(e_T - e_B)$. But the energy states that are associated with e_T and e_B are fixed wholly from thermal considerations; that is, by transfers of energy possible to the *thermal states* of the energy with which either the atom group or product molecule is associated. Thus another step has been taken toward the answer to the question concerning the possible variation of magnitude of the contributing quota Δe for any appreciable amount of the total release energy ΔE.

FRACTIONS OF THE TOTAL RELEASE ΔE FOR LARGE AND SMALL RELEASE QUOTA Δe

Since, from the present point of view, this problem reduces to that of discovering the part of ΔE which is released in terms of contributing quota for which $(e_T - e_B)$ is large as compared to that part for which this difference is small, the following conditions must be investigated:

(1) The distribution of the total thermal energy E_T before the reaction started, in terms of its contributing energy quota e_T of the atom groups entering to form later the product molecules.

(2) The distribution of the total thermal energy E_B after the reaction is complete in terms of its contributing energy quota e_B, each of which is associated with a product molecule.

(3) The thermal and chemical states which might exist between the states T and B.

Since Fig. 3 represents the energy distribution in equilibrium for any group of identical particles, it represents also the distribution of the energy E_B retained in the product molecules after combustion. Thus it will show the fractions $(1 - F)$ of this energy which are associated with large contributing quota e_B per product molecule as compared to those associated with small contributing quota. But the fractions $(1 - F)$ show also what parts of the total energy E_T are associated with contributing quota e_T per atom group, which are large as compared to those that are small, because each e_T involves exactly the same numbers of the several kinds of atoms which enter to form each product molecule. Thus this curve may also be used to show the distribution of energy E_T.

The probability that the part of the energy E_T associated with groups of atoms per resultant molecule in quota e_T which are very large will become, in the final state B, the part of the energy E_B which is associated with product molecules of which the quota e_B are very small, is, of course, the product of the probabilities of the energy in the two states. It is now possible to arrive at quantitative solutions for the general as well as for a particular case.

QUANTITATIVE VALUES FOR GENERAL CASE

Referring to Fig. 3,

$$e_T = u_\epsilon = 324; \; F = 0.17$$

thus but 17 per cent of the total energy E_T may be present in quota e_T larger than $u_\epsilon = 324$ units. The same curve shows that not more than

$$(1 - F) = (1 - 0.81) = 0.19$$

or 19 per cent of the energy E_B may be associated in the product molecules in quota per product molecule equal to or less than

$$e_B = u_\epsilon = 81$$

Therefore, not more than

$$0.17 \times 0.19 = 0.0323$$

or 3.2 per cent of the released energy ΔE may have the release quota Δe in which the thermal difference term $(e_T - e_B)$ is greater

than the difference in energy which the above e_T and e_B values represent.

The value e_B equals 81 may not, however, be subtracted, as it stands, from the value e_T equals 324, because e_B represents the energy of the products of combustion and e_T that of the constituents entering to form the products. Therefore, at a given temperature, the thermal energy contained in the one and represented by e_T may not be equal to the thermal energy contained in the other which is represented by e_B. Let

$$R = \frac{E_B}{E_T}$$

where E_B is the thermal energy of the products at the temperature under consideration and E_T the thermal energy of the same constituents at the same temperature but before combustion begins.

This is the number which relates the abscissa values of Fig. 3 for e_T to the same abscissa values when they are to represent e_B. Thus the difference between the foregoing abscissa-scale values of e_T and e_B may be stated in the form

$$(324 - R \times 81)$$

It is now possible to say that not more than 3.2 per cent of the released energy ΔE can contribute release quota Δe for which the thermal difference term $(e_T - e_B)$ is greater than $(324 - R \times 81)$.

By the same method it is found that the same percentage holds when

$$(e_T - e_B) = (81 - R \times 324)$$

Thus, in the one case,

$$\Delta e = e_C + (324 - R \times 81)$$

and in the other

$$\Delta e = e_C - (R \times 324 - 81)$$

But since e_C is a constant, it follows that not more than 3.2 per cent of the total released energy may be contributed in quota Δe which depart from the average by more than is indicated by what the values in the above parenthesis represent. How large these are in relation to the release quota Δe for a particular case will now be investigated.

General Quantitative Values Applied to a Particular Case

The following data[3] on the components of the thermal energy involved apply.

Heat content at one atmosphere pressure from 0 to 298 deg. cent. abs. per gram formula weight is 4050 joules for $\frac{1}{2}(H_2)$ and 8600 joules for $\frac{1}{2}(O_2)$.

Hence e_T per gram formula weight for the formation of H_2O is

$$2[{}^1/_2(H_2)] + {}^1/_2(O_2) = 2 \times 4050 + 8600 = 16{,}700 \text{ joules}$$

The heat of formation of H_2O per gram formula weight at 298 deg. cent. abs. is 286,000 joules, and at 0 deg. cent. is 282,000 joules.

Hence, by substituting above values in

$$\Delta e = (e_T - e_B) + e_C$$

the energy e_B per gram formula weight is found to be 20,700.

Then $R = E_B/E_T = e_B/e_T = 1.23$

Whence $(324 - R \times 81) = 224$ and $(R \times 324 - 81) = 378$

[3] International Critical Tables, vol. 5.

the latter being the larger number represents a larger fraction of the mean release energy quota Δe. Now

$$\frac{e_T}{\Delta e} = \frac{16{,}700}{286{,}000} = 0.0582 = 5.82 \text{ per cent}$$

which means that the mean value of the thermal quota e_T is 5.8 per cent of the release quota Δe. But on the scale of Fig. 3 the mean value of e_T falls under M at the scale number 162.

The above deviation of 378 units from the mean quota Δe thus represents

$$\frac{378}{162} \times 5.82 = 13.5 \text{ per cent of the mean } \Delta e$$

This means that for not more than 3.2 per cent of the total released energy ΔE may the contributing release energy quota Δe differ by more than 13.5 per cent from the average value of this quota as computed from the relation

$$\Delta e = \Delta E/N$$

where ΔE is the calorific value as measured in a calorimeter and N the number of product molecules formed in the combustion. If the combustion considered had been that of carbon to carbon monoxide, the percentage variation of Δe would have been somewhat larger but it would still have been under 25 per cent.

Although the limiting variations shown in the above result are based on the complete combustion of the constituents, the same conclusions may be applied when considered in the right way, even when the chemical equilibrium is such that the reaction ceases before combustion is complete for some parts of the combining constituents. For this case, part of the product molecules (those for which combustion is incomplete) release, on the average, quota Δe which are smaller than are those for the others in which combustion has been considered as complete. The total energy release is reduced and equals

$$\Sigma \Delta e_i + \Sigma \Delta e_B$$

in which $\Sigma \Delta e_i$ represents the part of it released by the quota for which the reaction is incomplete and $\Sigma \Delta e_B$ the part of it which is released by quota for which the reaction is complete. The distribution of the total released energy ΔE may be represented by two distribution curves. One of these shows the distribution of the part ΔE_i (released in incomplete combustion) in terms of the different possible magnitudes of Δe_i, and the other, the same relation between ΔE_B and Δe_B. Obviously, for each curve taken by itself, it will be found that the fraction of the part of the energy release which it represents, which may be released in quota Δe_i or Δe_B which differ in magnitude considerably from the average of either, will be negligibly small.

Thus up to this point in the investigation nothing has been found which could result in such special characteristics for the radiation emitted in combustion as were contemplated in the first part of this paper. The possible deviation of the release quota Δe from the average for any appreciable part of the total released energy ΔE is far too small. The effectiveness of this deviation is not a question of 20 to 30 per cent but rather one of 10 to 100 times. As an example, the X-ray quantum has a frequency and hence an energy roughly 1000 times as great as that of the average of the infra-red radiation. The probability will next be investigated of the existence between states T and B of an energy condition in which, momentarily, the energy distribution may vary so much from that which has been discussed that the results as computed from the equilibrium states at T and B do not apply.

(*To be continued*)

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS (See also Internal-Combustion Engineering: Fuel-Spray Aero Engine)

Air Transportation as Related to Business

OF THE three things that have to be attained to make air transportation popular, the first, in the opinion of the author, is safety; however, more than safety has to be secured. The following passages are quoted verbatim:

"We have to have people believe that they are safe; and one of the things that we must have in order for them to believe that is to make the planes comfortable. I have ridden as long as twenty hours in one day, practically without stop, just enough to take gasoline on, and when the day was over my bones ached and my whole nervous system was wearied from the noise, that constant droning of the propeller and exhaust in my ears. We will have to overcome that, and it is perfectly within the realm of reason to believe that we can eliminate not only the noise of the exhaust but also the noise of the propeller. That is one of the things we will have to do.

"The only reason why people use the subways in New York today is because they are cheap, not because they are comfortable; for the noise in the subway is worse than it is in an airplane. You cannot talk in a subway. In a good many airplanes you can talk; it is not very comfortable, but you can talk. But the subways are cheap; you can ride in them for five cents.

"Now that is the next step, we have to make our transportation by air cheap enough so that it will be an economical thing for the people to use.

"Today we are charging ten cents a mile, and it is costing more than that per passenger. A tri-motored ship costs about $1.10 per plane-mile. Most of our passenger-carrying companies are depending upon other things in order to get by. They carry twelve passengers if they are lucky enough to get them, and they charge those passengers ten cents a mile. That is $1.20 that they get for the twelve passengers, and they cannot make any money at that rate, because if they lose two passengers they lose money. But speed and design will change all that. Cheaper fuel costs will help change it.

"We have planes today operating in the middle and western parts of the country that we have accurate records of for months, carrying six passengers and pilot, flying at top speed of 180 miles an hour and an average speed of 145 miles an hour, and the cost of operating such a plane is 32 cents a mile; and when we get fuel costs down it will be less than 30 cents a mile. It carries six passengers, which is less than five cents a mile per passenger. That is getting down toward railroad costs. It costs about 6 cents a mile on the railroad, on the best Pullman trains, today. So we are going to make airplane travel cheap. . . . Busy executives cannot afford to use the slower means of transportation if they can safely, comfortably, and cheaply go from New York to Chicago in an hour and a quarter." (Address before the Fall Conference, Chamber of Commerce of the United States, Columbus, Ohio, Oct. 15, 1929, by Edward S. Evans, President of the Detroit Aircraft Corporation, pp. 3–10, *g*)

ENGINEERING MATERIALS

Concrete-Pipe Manufacture

THIS article deals with the practice of the American Concrete Pipe Co. as formed in 1929 by merging Western Concrete Pipe Co. with the Bent Concrete Pipe Co., and particularly with the Los Angeles, Calif., plant. The company manufactures three kinds of concrete pipe at this plant, namely, ordinary sewer pipe without reinforcement, Hume centrifugally spun pipe reinforced with wire, and precast reinforced pipe. Owing to the mild climate most of the manufacturing is done in the open and the work is continuous throughout the year. For making poured (precast) reinforced pipe, the steel rings for the bell are laid on the ground and the steel form for the inner surface of the pipe is set up in sections and clamped together. The outer form is then set up and clamped together and the reinforcing cage, which has been made up on the ground nearby, is dropped into the space between the forms and lined up by vertical spacers to keep the reinforcement in proper position. The surfaces of the forms are sprayed with oil to keep the concrete from sticking. In the larger pipes the reinforcing cage is elliptical in form and is lined up with spacers to get this result. The concrete is fed into the forms from a dumping truck that is arranged to dump the concrete from a height of as much as seven feet above the ground. The concrete is tamped in between the reinforcement with thin steel tampers. The forms are kept on for one day, when they are stripped off and the pipes kept wet for seven days. (James N. Hatch, *Concrete*, vol. 36, no. 5, May, 1930, pp. 27–29, illustrated, *d*)

Properties of Some Steels Containing Chromium

THE experiments described in this paper were carried out in the laboratories of the Birmingham Small Arms Co., Ltd., Birmingham, England, and were especially intended to determine certain properties of steels which might be suitable for exhaust valves of air-cooled internal-combustion engines. Among other things, material suitable for the purpose should have good mechanical strength combined with toughness at ordinary and elevated temperatures and resistance to oxidation or scaling at temperatures to which the exhaust valve may be heated under adverse engine conditions. This temperature may occasionally reach from 800 to 900 deg. cent. (1472 to 1652 deg. fahr.). Tests were made on a number of steels belonging to four classes, namely, plain chromium steels, silicon-chromium, high-nickel-chromium, and cobalt-chromium steels. From tests on steels containing silicon and chromium it would appear that at least 2 per cent of silicon must be present to prevent air hardening. On the whole it would appear that the presence of silicon tends to make a steel brittle but without impairing its strength. The steel is brittle when $3^1/_2$ per cent of silicon is present.

Nickel-chromium steels are of the austenitic type and the hardness is not affected greatly by heat treatment. These steels possess better static properties at elevated temperatures than the silicon steels. They are stronger and do not appear to be so plastic when hot. From the results obtained it would appear that there is little to be gained by increasing the nickel and

chromium content from 9 per cent to, say, 12 or 13 per cent. The elongation and reduction of area in the nickel-chromium steels at various temperatures are fairly constant, whereas in the case of silicon-chromium steels the values of these particular properties increase with increase in temperatures of testing, with the result that at 800 deg. cent. (1472 deg. fahr.) the nickel-chromium steel has a reasonable reduction of area, whereas silicon-chromium steel pulls out almost to a point.

The results with cobalt-chromium steel were rather disappointing in the one test made, as the steel was brittle on account of the high carbon content (1.14 per cent). The results of the Izod impact test at elevated temperatures have shown that heating improves the toughness figure. This was particularly striking in a plain chromium steel with 0.57 per cent carbon and 5.99 per cent chromium. The increase in toughness may be considered to be progressive. The introduction of silicon causes a reduction in impact values, while all the steels of the austenitic type show reasonably good values of impact strength.

An exact knowledge of the coefficient of thermal expansion of an engineering material is sometimes of value. In the case of steels for valves, an idea of the clearances required is obtained. Moreover, should a valve steel possess the same characteristics as the cast iron of the cylinder, perfect seating would be obtained at all temperatures. The expansions were first determined up to 100 deg. cent. in a steam-jacketed apparatus, and then up to about 900 deg. cent. by using a nichrome-wound furnace. In both methods the elongation of the specimen was magnified by means of a mirror and a beam of light. In the case of the apparatus for determining expansion up to 100 deg. cent., the movement of the mirror was effected by a fine wire passing round a pulley on the mirror shaft, which was held in jewel bearings; the wire was kept in tension by a light spring. In the other case, the mirror was attached to a rod which could roll between two flat plates, one being fixed and the other connected to the specimen by means of a silica rod. The specimens were heat treated, according to the previously determined schedules, before the determination of the expansion. The contraction on cooling was also observed, but it is not possible to show these results without the use of a separate graph for each steel.

The bending over of the curves at about 800 deg. cent. is due to the temperature approaching that of tempering. Quite erroneous results can be obtained unless the steels are heat treated between experiments.

It is interesting to note that: (1) Invar has a low coefficient of expansion only at temperatures up to about 120 deg. cent. (2) The coefficient of expansion of all the specimens examined increases with rise of temperature. (3) There is not much difference in the expansion of any of the silicon-chromium steels examined. (4) The high-nickel-chromium steels have a very much greater coefficient of expansion than the other chromium steels. Some of the steels suffered permanent changes of length. For example, steel *C* decreased 0.003 in. and steel *E* 0.001 in. on a length of 2.75 in., whereas steel *N* did not undergo any change. The amount of displacement of the cooling curves confirmed these contractions. (A. R. Page and J. H. Partridge, Ph.D., in a paper before the Iron and Steel Institute, London, May 2, 1930. Compare *Engineering*, vol. 129, no. 3358, May 23, 1930, pp. 680–683, 10 fig., *e*)

FOUNDRY

The Poumay Cupola

THE characteristic feature of this cupola is that incomplete combustion to carbon monoxide is deliberately provoked in the lower part of the cupola to avoid oxidation in the melting zone. Instead of getting, as in the case of an ordinary cupola, combustion of carbon and oxygen to carbon dioxide under the melting zone, in the Poumay cupola carbon monoxide is produced under the melting zone and the drops of iron have to transverse a zone of reducing atmosphere before reaching the well of the cupola, whereas in an ordinary cupola, the drops of molten iron have to pass through an oxidizing atmosphere. (Discussion at the meeting of the Scottish Branch of the Institute of British Foundrymen of a paper on the Poumay cupola by John Cameron; including a letter from M. Poumay, quoting, among other things, a paper on the Poumay cupola by Prof. C. Geiger, which appeared in *Die Giesserei*, vol. 33, Aug. 17, 1928, pp. 816–819. Abstracted through *Foundry Trade Journal*, vol. 42, no. 716, May 8, 1930, pp. 338–340, first instalment, *g*)

FUELS AND FIRING

Selecting Fuels for Pulverized-Coal Installations

THE author considers the belief that in a pulverized-coal plant any coal can be burned successfully is incorrect, because it is incomplete. Specially designed plants can be made to handle practically any grade of coal down to lignites, but they require particular design, such as special spacing of tubes in the lower sections of the boilers to prevent an excessive amount of slag bridging across them. It would be more correct to say of pulverized-coal installations that while any grade of coal can be burned in them, each plant, according to the fuel it is designed for, has a definite range of coals that must be used if efficiencies, grinding costs, upkeep charges, and smoke and fly-ash troubles are to be kept where they should be.

The general belief that the higher the volatile the more suitable the coal, is incorrect. To obtain rapid combustion, fast flame propagation is essential, and this depends primarily on the ignition point of the fuel. From the standpoint of ignition a true bituminous coal is desirable.

Once combustion of the fixed carbon is started, the heat produced causes ignition of the various volatiles, the ignition points of which vary from 900 deg. to somewhat over 1200 deg. for all those of any appreciable quantity. From that point on the higher heat of combustion of the volatile speeds up and sustains the burning of the solids.

After an analysis of the various factors that enter into the combustion of fuel such as stratification of the gases and character of the flame, the author comes to the conclusion that the following specification for coal for installations designated for pulverized bituminous coal would be preferable.

Structure: As friable and soft as can be obtained with other specifications.

Burning Characteristics: Flashy, fast flame propagation.

Volatile Content: From 20 to 27 per cent.

Ash: Not over 8 per cent, fusion temperature as indicated.

Heat Value: Not less than 14,000 B.t.u. per lb.

Moisture: Not over 3 per cent. There are a number of successful installations employing coal running high in surface moisture, but the designs have been adopted to meet these conditions.

And, of course, the coal must be clean.

The author is careful, however, to point out that this coal in itself will not always produce highest economies unless the design of each detail of the entire plant is properly selected.

Ash, always a dead loss in coal burned in any form, causes still further loss when the coal is burned in pulverized form by its smothering action on ignition and flame propagation. The ash also adds greatly to furnace upkeep, if its fusion point is too low, by causing slagging. The necessary fusion points for different rates of heat liberation per cubic foot of furnace volume for various types of furnaces are:

	Liberation per cu. ft., B.t.u.	Fusion temperature, deg. fahr.
Solid walls	10,000–12,000	2000–2500
	12,000–16,000	2500–2700
Air-cooled walls	12,000–16,000	2000–2500
	16,000–22,000	2500–2700
Water-cooled walls	Up to 20,000	2200
	20,000–30,000	2200–2700

These rates of heat liberation are averages for the entire furnace volume. They are for furnaces not equipped with water screens or cooled zones.

Sulphur, usually regarded as a scapegoat, is really beneficial in pulverized-coal-boiler installations, particularly when in vegetable form, as it aids quick ignition and flame propagation. The exceptions to this are where economizers or air preheaters are used, to which it is harmful, and where the coal is weathered for a long time and the sulphur, if pyritic, changes to inert sulphate. However, in the latter case it is too small in quantity to be important. (C. H. Camp, Combustion Engr., W. A. Marshall & Co., in *Power*, vol. 72, no. 2, July 8, 1930, pp. 55–57, 1 fig., *p*)

HYDRAULICS (See also Petroleum Engineering: Fluid Flow and Friction in Pipe Lines)

Draft-Tube Tests

THE subject of draft-tube tests was assigned in 1925 for investigation to the Hydraulic Power Committee of the New England Division of the National Electric Light Association. Under the limitations adopted the Committee sees no reason to attempt a discussion of the relative merits of various type of tubes or comment on the general subject of draft-tube design. It is believed that the data presented in this report demonstrate the importance of tests of model turbine settings and their value in working out draft-tube designs to meet specific space requirements.

In working up a turbine proposition each manufacturer will have certain space requirements, particularly as to depth of tailrace and spacing of units, which he can depart from only at sacrifice in efficiency. The requirements of various manufacturers rarely agree, and the purchaser is compelled to make allowances for differences in concrete and excavation and evaluate variations in efficiency in order to arrive at a fair comparison of bids. This is fundamentally wrong, for the economics of the local conditions should be allowed to fix the depth of excavation and the spacing of units, and all manufacturers should be in position to fit their turbines into any reasonable space available.

The evidence is that the present state of affairs is entirely unnecessary and that adequate investigation by means of model tests will insure a satisfactory tube for practically any condition. This is certainly true in the instances on which the Committee has data available, high-efficiency tubes having been developed for heights varying roughly from two to four times the throat diameter, with widths from two to four times and lengths from three to seven times the same quantity, and there is no reason to suppose these are limiting ranges.

If there existed a more general appreciation of the benefits to be obtained by working up a custom-made tube for every important individual installation, rather than adopting the nearest ready-made approximation the manufacturer has available, tests would be much more generally resorted to. The expense of such tests is insignificant in comparison with the resulting reduction in installation costs and improvement in operating efficiency. It should be pointed out, however, that these benefits accrue primarily to the purchaser rather than to the manufacturer, and the purchaser is the one who must demand them and should be willing to pay for them.

Very early in its investigation the Committee was impressed with the difficulty of comparing draft-tube tests derived from different sources and cast about for some means to improve conditions in this respect. There resulted the suggestion that a reference be included in every series of draft-tube tests, to serve the purpose of a yardstick in facilitating comparisons. The relation between the results obtained with such a tube and with any other tube under consideration might give an indication of the relative merits of the latter and might permit the comparison of test results obtained in different flumes. The data collected by the Committee emphasize the desirability of such a yardstick, which would tie all class A (small model draft tubes without runners) tests together and would certainly give a much better inkling of the relative merits of the various class B (model tubes with model runners) tubes that can now be obtained. The idea of the reference tube has been criticized on various grounds, principally due to a fear that comparisons might be misleading and might be used to the detriment of certain types of tubes and runners. It is claimed that the tube which proves best with one runner may not prove best with another, though no definite evidence on this point has been presented. Whether or not the variation in performance would be of some magnitude or entirely negligible, however, is something on which no information is at present available, and on which experience only can throw any light.

A bibliography on the subject of draft tubes is appended to the report. (National Electric Light Association Report of the Hydraulic Power Committee on Draft-Tube Tests, publication no. 047, May, 1930, 17 pp. including bibliography, illustrated, *eA*)

INTERNAL-COMBUSTION ENGINEERING

Centrifugally Cast Cast-Iron Cylinder Liners

THE problem of rapid cylinder wear is a very serious one for designers of vehicles, particularly in the case of the long-distance coach with its powerful high-speed engine. Aluminum or other light-alloy pistons are used in practically every instance, and the author of the article claims that cylinder wear is increased at least 25 per cent when aluminum pistons are adopted. Commercially this is outweighed by the economy of fuel oil and general engine efficiency. It is said that the most successful method to obviate excessive wear is the use of cylinder liners made of centrifugally cast iron. In this method of casting all dross and impurities are thrown to the inside and are removed in the machining operation.

Two types of liners are used, usually designated as "wet" and "dry." A "wet" liner is used in cylinder blocks designed to hold the liner in place, and in this case the outside of the liner is in contact with the cooling water. The wet liner is usually pressed into the "skeleton" cylinder casing, but rubber rings are also sometimes used.

The use of wet liners has much to recommend it, as scrap percentages are cut down and better-wearing and replaceable cylinder bores are obtained. It is, however, a "factory" job; that is to say, the cylinder block must be designed for wet liners from the first stroke on the drawing board.

This is not the case with the "dry" liner, which is merely a shell of centrifugally cast iron, usually with a wall thickness of $^1/_{16}$ in. The cylinder is bored out and the dry liner pressed in hydraulically, after which it is ground to size in the bore. This is a very simple process which is being used extensively by operators and manufacturers alike.

The original article contains some photomicrographs, not previously published, which show an alloy cast iron that can be heat

treated to such a degree that, in the words of the author of the article, "it can be confidently claimed to be virtually of hardened and tempered steel containing clusters of finely divided graphite." From these photomicrographs it would appear that in the normal cylinder iron the structure is of the usual soft pearlitic type containing free ferrite, while the hardened liner has an entirely martensitic matrix. The hardened liner is impervious to attack with a file. (*Motor Transport*, vol. 50, no. 1318, June 16, 1930, pp. 718–719, illustrated, *d*)

A Fuel-Spray Aero Engine

THIS is a 425-hp., modified Pratt & Whitney Wasp, nine-cylinder, radial, air-cooled engine, so arranged that it is on the border line between the conventional gasoline and the Diesel engine. It uses gasoline or fuel oil as a fuel, but it has no carburetor and employs instead a fuel-injection system. On the other hand, moderate compression and spark ignition are retained.

The injection of fuel occurs early in the compression stroke—about 75 deg. ahead of dead center, according to one report—so that more time is available for vaporization than in a Diesel engine of ordinary construction and comparable rating. As the compression pressure and temperature are kept below the ignition point both of the gasoline and of the fuel oil used in the test, the occurrence of ignition remains under the control of the electric spark, while switching over from one fuel to the other without stopping of the motor is made possible. In this feature is seen an important point of divergence from the usual form of Diesel engine, where the timing of injection is more directly related to the timing of ignition. Because of the lower compression, also, the high-economy characteristic of the Diesel engine is considered to be sacrificed—in fact, the spark-ignited engine is likely to consume considerably more fuel oil than gasoline. According to observers witnessing the demonstration flight of this engine, the moment at which the pilot switched over from fuel oil to gasoline could be distinguished from the ground by the disappearance of smoke at the exhaust. It is reported also that the cold engine will fire promptly after gasoline begins to be injected, but that the engine will not fire on fuel oil unless the latter is switched on after the motor has been previously warmed up by running on gasoline. Two kinds of fuel would be needed, therefore, while the elimination of fire hazard is not as complete as in the case of the Diesel engine with compression ignition.

The possibility of retaining low engine weight and avoiding the development work needed for a thorough-going application of the Diesel principle to aircraft propulsion is probably the major factor in the retention of low compression and spark ignition. At the present time there are two principal tendencies as regards maximum pressure observable in the development of fuel-oil-burning internal-combustion engines. On the one hand pressures are being pushed up in the belief that the resulting increase in efficiency and specific output will overbalance the additional engine weight required. On the other hand, efforts are being made to limit maximum pressures for the sake of keeping engine weights down. Which of the two viewpoints will ultimately be sustained by practical performance remains to be seen.

The particulars of the injection system of the engine are not revealed. It is said that the engine cylinder has been modified very little other than by the addition of a spray valve which is said to be supplied with an impact fuel pump working according to a principle applied many years ago by S. A. Hasbrouck, who is now on the Pratt & Whitney staff. This, however, is not definitely known. The engine was demonstrated on April 8, 1930, and installed in a Boeing biplane. (*Diesel Power*, vol. 8, no. 6, June, 1930, pp. 306–307, 3 fig., *d*)

Engine Foundations for Diesel Plants

A METHOD of proportioning an engine foundation has been determined on the basis of the weight of the engine and its speed. The formula, as given below, gives the weight of the foundation required. The minimum horizontal area and the depth should be determined in accordance with the following equation:

$$W_f = CW_e\sqrt{N} \quad [1]$$

where W_f is the required weight of the foundation in pounds, W_e the weight of the engine in pounds, N the speed of the engine in revolutions per minute, and C a constant given in Table 1. The table has been prepared from a wide variety of engines and their foundations.

The formula for the necessary volume of a concrete foundation is

$$V_f = cW_e\sqrt{N} \quad [2]$$

where V_f is the volume of the concrete foundation in cubic feet, W_e the weight of the engine in pounds, N the speed of the engine in revolutions per minute, and c a constant given in Table 1.

TABLE 1 FOUNDATION CONSTANTS

Number of Cylinders	Position	Type	C	c
4	Vertical	Gas	0.130	0.000975
3	Vertical	Gas	0.150	0.001130
2	Vertical	Gas	0.175	0.001310
4	Vertical	Diesel	0.177	0.001330
1	Horizontal	Semi-Diesel	0.300	0.002250
2	Horizontal	Semi-Diesel	0.240	0.001800
3	Horizontal	Semi-Diesel	0.230	0.001730
4	Horizontal	Semi-Diesel	0.225	0.001690

Following is an example showing how to use these equations to compute the required weight and volume of the foundation for a four-cylinder vertical Diesel engine weighing 125,000 lb. including the generator. To find its minimum depth if made with straight vertical sides, Table 1 is referred to, whence $C = 0.177$ and $c = 0.001330$. Hence, by Equation [1]

$$W_f = 0.177 \times 125{,}000 \times \sqrt{325} = 357{,}482 \text{ lb.}$$

also by Equation [2]

$$V_f = 0.001330 \times 125{,}000 \times \sqrt{325} = 2995 \text{ cu. ft.}$$

(K. W. Schultz, in *Diesel Power*, vol. 8, no. 6, June, 1930, pp. 300–302, 5 figs., *p*)

MACHINE TOOLS

A British Combination Turret Lathe

IT IS ONLY quite recently that Alfred Herbert, Ltd., of Coventry, England, has succeeded in producing a combination chucking machine with protective slide ways. The machine represents what is claimed to be a new departure in turret-lathe design. The bed, which is a rigid dry-sand casting, has four guiding surfaces—two for supporting the set and two for the turret slide. Of these four guiding surfaces three are of inverted V-shape, while the remaining surface, located to the rear of the bed, is of square section with a flat top face. The surfaces are completely protected from chips, dirt, and injury by covers attached to the saddle and turret, respectively, a point about the design being that the covers actually slide upon the guiding surfaces and are not merely arched over them. As a consequence the presence of even fine chips or dirt is prevented.

The covers attached to the saddle pass through clearance recesses under the saddle. The covers of both saddle and turret slide clear the headstock by passing underneath or beside it. This arrangement is said to give complete protection to the

bed without in any way restricting the relative movements of the slide members and also enables the saddle to be brought close to the chuck. The bed form is designed so as to permit of liberal openings without obstructions for the escape of chips.

The method of finishing the bed is by surface grinding, and the bed itself stands on a steel tray of liberal proportions, being supported by feet embodying a three-point principle. The result of this is that the bed is perfectly free to accommodate itself to any unevenness in the foundation, and in putting the machine down it is not necessary to level the bed in the ordinary way.

As regards the saddle, it has, in addition to the chasing mechanism, also self-contained reversible automatic feeds operating longitudinally and transversely. The feeds are driven from the main spindle through gearing embodying suitable safety devices. To change and reverse the feeds, levers are mounted on the saddle apron in a manner particularly convenient for the operator. (*Machinery* (London), vol. 36, no. 921, June 5, 1930, pp. 297–299, illustrated, *d*)

MARINE ENGINEERING

Analysis of Condenser Troubles

IN THE author's opinion, water circulation in surface condensers has been more or less neglected, not so much by builders of condensers, because generally water boxes are of ample capacity and of suitable design with openings for inlet and outlet properly placed, but through faulty connections made during installation, especially in the marine-power-plant field. Engineers often have little or no opportunity of installing the condenser in a suitable place as regards both steam and water circulation, with the result that the condenser is installed in the best available place and the steam and water connections are often of an improper character. This is an important factor in the cost of condenser maintenance and efficiency. The trouble with water circulation often starts at the injection strainer and is aggravated as it follows its cycle into the sea chest and through the circulator and condenser, and even to the point of leaving the ship's side.

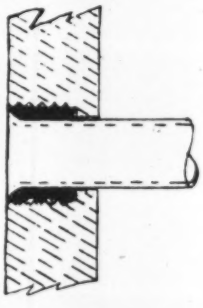

FIG. 1 A METHOD OF SECURING CONDENSER TUBE IN TUBE-SHEET INLET

The author discusses various methods of securing and packing tubes in the tube sheets of surface condensers. The first method—drilling and tapping tube sheets and making ferrules—is the common one and is poor design. A better design is the one in which the stuffing box is tapped only half of its depth and the ferrule is smooth for about half of its length. Another method is that of packing a condenser tube with a fiber expansion ring at the bottom of the stuffing box and then using a metal ring calk in imbedding the metal in the thread. Next the condenser tube may be expanded into the tube sheet with the tube end belled to secure streamline flow. This method is usually employed on the inlet side only. Several other methods are described, the only one of particular interest being that shown in Fig. 1.

Fig. 1 represents a condenser tube secured in the inlet tube sheet without expanding the tube or using a ferrule. A cotton-fiber bushing is driven over the tube into the stuffing box; this is followed by a metal ring calked into place, securing the bushing in place and bonding the tube to the tube sheet and offering a soft metal on which to bell the end of the tube. The tube is then tapped back so that the belled portion enters the tube sheet, making the tube sheet smooth and all the tube ends flush; and the lip formed in belling forces this soft metal ring to fill all voids so there is no place for corrosive gases to collect at the tube end. This method of securing the inlet ends of tubes prevents the tubes from moving or creeping and maintains a vacuum-tight joint under all operating conditions. The tube structure is not changed in any way, vibration is absorbed by a soft, resilient, cotton-fiber bushing which will tighten itself in the event of drying out due to overheating simply by bringing moisture in contact with it again, and in retubing a condenser the tubes can be removed very quickly without danger of damage to threads, bore of stuffing box, or tube sheet. (First part of a serial article by Graham Smith, West Coast Manager, Crane Packing Co., in *Pacific Marine Review*, vol. 27, no. 6, June, 1930, pp. 237–239, *pc*)

METALLURGY (See also Engineering Materials: Properties of Some Steels Containing Chromium)

New Process for the Manufacture of Copper Wire Bars

WIRE bars are usually made by remelting of copper cathodes. Instead, however, of making it a straight remelting process the present standard practice does it practically in the form of a supplementary refining operation which takes a very long time and is not always satisfactory. Moreover the operation is such that it is necessary to empty the furnace very rapidly, which necessitates the employment of casting machines and casting the billets horizontally.

The induction furnace (such as the Ajax-Wyatt), which can now be made to operate at comparatively low frequencies, has proved to be very satisfactory for copper alloys but not for pure copper, which, the author explains, is due to the formation of copper sub-oxide, which vigorously attacks the furnace lining.

The author claims that he has developed a lining which is attacked neither by copper itself nor by copper sub-oxide and that this makes the use of the induction furnace for copper melting quite suitable.

The second improvement which he introduces and which is made possible by the new method of melting, is casting the wire bars on a vertical axis. (He quotes similar work described by J. Walter Scott and L. H. deWald in a paper before the 1930 meeting of the American Institute of Mining and Metallurgical Engineers, Technical Publ. No. 289.)

In experimenting on this new process, rectangular ingots were cast in a mold 100 × 100 mm. (say, 4 × 4 in.). The ingots were then rolled to wire rods of 6 mm. diameter (say, $^1/_4$ in.) at a temperature of 800 deg. cent. (1472 deg. fahr.) and then drawn down, cold, to 3.56 mm. diameter (0.138 in.). All the ingots could be worked without any trouble. A table in the original article gives data on the tensile strength, elongation, bending, torsion, and electrical conductivity of ingots manufactured in the manner described by the author, as well as photomicrographs of the material so made. (M. Tama in *Zeitschrift für Metallkunde*, vol. 22, no. 6, June, 1930, pp. 207–109, 1 fig., *d*)

MOTOR-CAR ENGINEERING

British Fluid-Transmission Devices of the Reaction Type

SEVERAL hydraulic devices were subjects of recent experiments in England. Two of them are described here. The first is a form of hydraulic coupling intended to displace the usual clutch forming a unit with the flywheel and adopted by the Daimler Company of Coventry. This device enables the car to be started on high gear by merely depressing the accelerator pedal and releasing the brakes. It operates together with a single-plate clutch which is, however, separated from the flywheel and used

only for changing gears and not for starting and stopping. On the level, with the engine running at idling speed, the car may be left in high gear and the brakes off and yet it will not move. The details of the actual design are not shown, but it is stated that the flywheel forms an oil chamber within which are two parts moving independently and constituting the driving and driven members, the former being attached to the casing. The driven member is flange-fixed to a shaft running back to the small cone clutch and a four-speed gear set. The two internal members resemble annular troughs, cup-like in section and face to face, and are divided into a large number of cells by radial webs. A small gap separates the two members, so that the driving one may rotate freely in relation to the other.

Assuming the car to be stationary and the engine running, rotation of the driving member by the engine causes the oil in its cells or cups to flow upward toward their outside periphery. From there, as the driven member is still stationary, the oil flows past the outside periphery of its cups, through them, and past their inside periphery to the inside periphery of the driving-member cups, and from there back again to their outside periphery. In other words, the oil starts on a circulatory motion between the cups of driving and driven members. In passing from the webs of the driving to those of the driven member, the oil is retarded in velocity and therefore releases kinetic energy, which sets the driven member in motion when the engine speed is high enough. Since even when the driven member has attained full speed the load on it causes it to lag behind the driving member, the centrifugal forces in the latter are always larger than those in the driven member, so that the circulatory motion of the oil, and therefore the transmission of power from the one to the other, is always kept up.

Another hydraulic device known as the Vickers-Coates hydraulic torque converter is of the turbine-transmission type, and consists of three elements—the primary, which is a rotating casing that encloses the whole of the mechanism; the secondary, or driven element, which is a centrifugal pump delivering fluid to a turbine and which is attached to a flange at the front end of the transmission shaft; and the third, which returns the fluid from the turbine to the pump. Both the primary and the secondary elements have fixed vanes secured to their inner peripheries. The primary delivers the fluid to the vanes of the secondary element, the latter, in effect, being a turbine to which a rotary motion is given by the fluid impinging upon its vanes.

Direct drive is afforded by dog teeth on the flanges of the crankshaft and transmission shaft, respectively. They are brought into engagement by a spring. Axial movement of the transmission shaft for this purpose also causes the secondary element to move away from the other two, though this is purely incidental.

In operation, as the engine speed is increased the torque is increased, since the delivery of the fluid to the secondary (driven) element increases. Actually, the input horsepower increases as the cube of the speed, the output torque increasing as the square, while the output torque can be as high as three and one-half to four times the input torque. This gives a continuously variable "gearing."

The change of ratio (i.e., the increase of torque) is automatic, since increase of loading at the road wheels slows the transmission and the turbine moves more slowly in relation to the primary. The transmission, of course, can be stalled by overload, but the engine cannot thus be stopped; therefore the engine is protected from overloading at all times.

At idling speed the engine does not pump sufficient fluid into the turbine to drive the vehicle. The latter commences to move as the brake is released and the accelerator is opened. This transmission of itself does not provide a reverse motion; for the latter purpose a separate reversing gear is used which may be coupled with a supplementary train of gears to afford an extra low gear ratio for trucks.

Engine braking effect with a closed throttle is afforded only when the dog clutch is engaged; when the turbine is in use the vehicle overruns, as in the case of a gasoline-electric transmission. (M. W. Pourdon in *Automotive Industries*, vol. 62, no. 24, June 14, 1930, pp. 908–909 and 917, 3 figs., *d*)

PETROLEUM ENGINEERING

Fluid Flow and Friction in Pipe Lines

THIS is an extensive and interesting paper—more in the nature of a treatise than a magazine article. It was first published in a briefer form in the October 7, 1926, issue of *The Oil and Gas Journal*. There was such a demand for copies that the author was asked to reprint it in a revised form, which resulted in the article here abstracted.

After referring briefly to the work of Poiseuille and Reynolds, the author devotes considerable attention to the formulas of Stanton and Pannell as confirmed by Landers' experiments and experimental work done at the Massachusetts Institute of Technology. The author believes, however, that the M.I.T. coefficients are too high for operating oil pipe lines of sizes 6 in. and larger. The author himself experimented in 1923 and 1924 to determine the friction loss in transportation of crude oil through steel tubes of 7.98 and 12.02 in. inside diameter.

The results of these experiments, which were confined to the turbulent-flow region, were consistent and followed the trend of the Stanton-and-Pannell curve, the values lying along or slightly below it. The results were consistently lower than the data of Kite and Kennedy. The experiments were made on lines which were a part of a long pipe-line system. Since the experiments were made, operating data on about 3000 miles of oil trunk lines, varying in nominal diameter from 6 in. to 12 in. and carrying crude oils from 30 deg. to 42 deg. A.P.I. in density, have been studied and the coefficients of friction have been found to lie closely along the Stanton-and-Pannell curves.

All experimental work to date has shown conclusively the existence of a similarity in the motion of fluids flowing in similar containers under widely varying conditions. This work has covered fluids from gases to heavy viscous oils flowing in tubes varying from small diameters used in laboratory tests to operating pipe lines as large as 12 in. in diameter. It has been demonstrated also that there are the two regions of flow and that the coefficient of friction is a function of the ratio dvs/u (Fig. 2). With this general principle established, the mechanism of the flow may be considered.

Further reference to Fig. 2 will aid in explaining the modes of flow. Two distinct branches of the curve, each representing a condition of flow, are shown.

The values of f, the coefficient of friction, corresponding to the values of the ratio dvs/u, which make up the curve ab, follow a distinct trend and fall near the curve up to a value of about 2000 on the abscissas, where the values of f change abruptly from the trend of the curve ab and become considerably higher at this point. The values of f between 2000 and 2500 follow no trend and are confused—this interval represents the transitional period from streamline to turbulent flow. It is interesting to note that for the smaller sizes of pipe there is a tendency for streamline flow to persist beyond the value of 2500, where, for most cases in Stanton and Pannell's experiments, turbulent flow sets in.

The branch cd of the curve begins with a higher value of f than the end of the streamline-flow curve, decreases rather rapidly at first, but gradually becomes parallel with the abscissa, indicating the tendency of the value f to be independent of the dimensions of the fluid as well as its temperature and to vary as

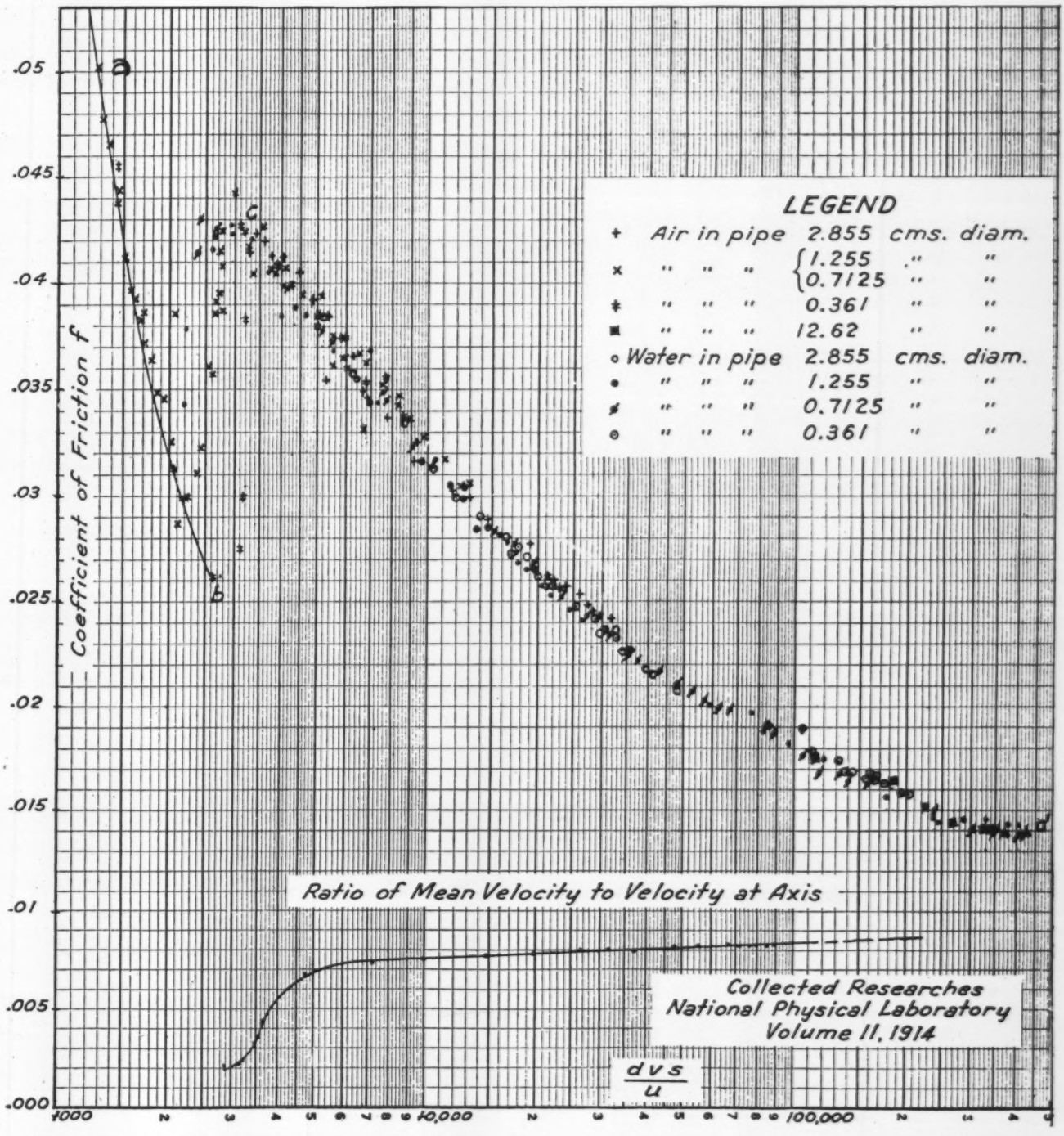

FIG. 2 SIMILARITY OF MOTION IN RELATION TO SURFACE FRICTION OF FLUIDS. BY STANTON AND PANNELL. FROM COLLECTED RESEARCHES, NATIONAL PHYSICAL LABORATORY, VOL. 11, 1914

(d = inside diameter in feet; v = velocity in ft. per sec.; s = density in lb. per cu. ft.; u = absolute viscosity in ft.-poundal-sec. units.)

the square of the velocity as the ratio dvs/u approaches some high value. The point at which the index law becomes effective has not been determined experimentally. The experimental results on curve cd from the value 2500 to 470,000 on the abscissa, with a few exceptions, show no greater variation than 2 per cent from the mean value for the various conditions. These data show a remarkable consistency considering the varying conditions, and the similarity of the motion of fluids in this region is thoroughly demonstrated.

It appears from the Stanton-and-Pannell data that the transition from streamline flow to turbulent flow occurs in the range from 2000 to 2500 on the abscissa. There is, however, an indication of a tendency for streamline flow to persist beyond the critical velocity for small pipe. This work would indicate that the critical velocity sets in at about 2000 on the abscissa, and that a post critical velocity, or the point at which turbulent flow begins, is at about 2500 on the abscissa. However, the experimental work carried out at the Massachusetts Institute of Technology on 1-in., 2-in., and 4-in. commercial steel pipe with oil indicates that the critical velocity sets in as low as 930 for the ratio dvs/u.

This work also indicates transitional values of f for a region between approximately 930 and 3100 on the abscissa. These experiments showed a wider range of limits for the transition from streamline to turbulent flow than was indicated in the work of Stanton and Pannell. It is believed that there is no inconsistency here, for turbulence would probably be set up in the small sizes of commercial pipe earlier than in smooth brass pipe of the same size. The roughness of the pipe is probably a factor in determining the critical velocity. In the case of the large pipe, however, it is believed that the transitory region will conform with the observations of Stanton and Pannell for smooth brass pipe of the same size. The roughness of the pipe is probably a factor in determining the critical velocity. In the case of the large pipe, however, it is believed that the transitory region will conform with the observations of Stanton and Pannell for smooth brass pipe, since the roughness of the large pipe will be a small factor compared with the smaller sizes of pipe. There is a possibility also that the pulsation of pumps or any disturbance at the source will aid in setting up a critical velocity at a lower value of the ratio dvs/u than where the source is under a steady and non-impulsive head.

The author gives formulas for the streamline flow where he believes that viscosity is the determining factor in the friction loss, while the density of the fluid is negligible. As regards turbulent flow, he thinks that the density of the fluid influences the resistance to flow rather than its viscosity. This does not apply probably to the thin layer of the fluid flowing in a streamline fashion along the wall of the tube. There are no data available to prove the existence of the streamline film of oil moving along the wall of the tube. However, Stanton, Marshall and Bryant, and others obtained experimental results that would indicate that there is such a film and it would appear that even in turbulent flow there is a region near the surface of the pipe in which the fluid is moving in a streamline fashion. This is also indicated by the fact that crude-oil pipe lines accumulate a coating of paraffin on their walls.

The author has found that the Stanton-and-Pannell curve for coefficients of friction is quite accurate for the design and operation of oil trunk lines varying in size from 6 to 12 in. in nominal diameter and carrying crude oils varying in density from 30 to 42 I.A.P. It is the author's conclusion that although we do not have a complete knowledge of the mechanism of turbulent flow, the friction loss for this condition of flow can be determined by the turbulent-flow formulas offered in this paper. These formulas incorporate the coefficient-of-friction factor which is determined from the Stanton-and-Pannell curve.

It appears that, from an examination of experimental data and an analysis of streamline flow, the roughness of new commercial steel pipe has a negligible effect upon the resistance to streamline flow. Graphical representation of experimental data obtained to show the relation of the coefficient of friction f to the ratio dvs/u for streamline flow in pipes of different degrees of roughness indicates that all of the points fall nearly on the same smooth curve. This would indicate that the roughness of the pipe is a negligible factor in streamline flow; however, this is not the case for turbulent flow. It is believed that where commercial pipe of the same interior roughness is used, the smaller pipe should show the higher coefficients for turbulent flow, and that above a certain size of pipe the friction loss becomes almost independent of the interior roughness of the pipe, acting the same as small smooth pipe. It is believed that the experiments with large sizes of pipe should give results similar to those obtained by Stanton and Pannell.

The author next develops formulas for streamline flow and turbulent flow. He also discusses the various aspects of the viscosity problem and gives a curve recommended for coefficient-of-friction values. This part of the paper is not suitable for abstracting. The following conclusions and recommendations are reported here.

The method of determining the friction loss, as outlined in this paper, is applicable to the flow of homogeneous viscous liquids through long lengths of tubes.

The method does not hold for short tubes (less than 1000 diameters in length) on account of the entrance and discharge losses accounting for a large part of the friction loss through short tubes.

The use of the method requires that the physical factors for each individual case be known; it is important that the characteristics of the liquid for each case be known.

For heated liquids the viscosity and density changes due to the loss of temperature along the line must be considered.

The method holds for gases only when there is no great difference in the initial and final pressures, which would result in a change of temperature, density, and rate of flow of the gas.

It is believed that some further research work should be carried out to determine whether one coefficient-of-friction curve in the turbulent region will satisfy all sizes of commercial steel pipe used in the industry, or whether the effect of the roughness factor is variable with the diameter of the pipe and a family of curves is necessary, possibly, for the smaller sizes of pipe.

The work of Bridgman on the viscosity of liquids should be extended to include crude oils at pipe-line operating pressures. Further information on the viscosity of crude oils under pressure will be helpful in the design of pipe-line systems.

A further study should be made to determine the relation of the coefficient of friction f to the ratio dvs/u in the transitional régime between turbulent and streamline flow, and to establish the limit of this transitional régime for operating oil pipe lines of various diameters. It is important that pipe-line engineers know definitely where streamline flow ends and where turbulent flow begins. Pipe-line engineers should know more about the coefficient-of-friction values in the transitory régime. A cooperative investigation, sponsored by the pipe-line industry, of the problems outlined above should provide the pipe-line engineer with some valuable data for the design and operation of pipe-line systems. (A brief bibliography on the subject is appended to the original article.) (Wm. G. Heltzel in *The Oil and Gas Journal*, vol. 39, no. 3, June 5, 1930, pp. T203–T224, 13 figs., *peA*)

POWER-PLANT ENGINEERING (See also Internal-Combustion Engineering: Engine Foundations for Diesel Plants)

Investigation of Consumption of Cooling Water in Surface Condensers

PRIMARILY the weight of flow of cooling water is determined by the quantity of steam condensed. This leads to the establishment of a certain ratio between P, the weight of cooling water, and p, the weight of steam to be condensed. The normal value of the ratio P/p is usually contained between 60 and 65 for the maximum output of the apparatus in continuous operation. The factors which tend to affect this ratio (with due regard to a search for the lower cost per kilowatt-hour) are as follows:

Factors increasing P/p are: Effort to obtain a higher vacuum with condenser of reduced active surface; higher temperature of circulating water; dirty cooling water, requiring faster water circulation in order to increase the periods between cleanings; maintenance of a more constant vacuum where sudden large peak power demands are present.

The author suggests obvious ways to counteract these factors and reduce P/p when possible, as, for example, by a substitution of clean water for dirty cooling water. With water at 15 deg. cent. (59 deg. fahr.), which is the average temperature of water in

French rivers, condensers built by the writer's concern furnish a vacuum of 96 per cent, assuming the barometric pressure to be 760 mm. of mercury with a ratio P/p of about 60. This value depends on the number of calories contained in a unit weight (1 kg. = 2.2 lb). of steam in the condenser, this quantity varying slightly with the amount of moisture in the steam at the end of the expansion, which depends in turn on conditions of pressure and temperature of the steam entering the turbine and the efficiency of the latter. If, for example, the steam expansion is pushed to about 96 per cent of the barometric pressure at the condenser tubing, which can be done with cooling water at 15 deg. cent. (59 deg. fahr.), and the moisture in the steam at that pressure is 7.5 per cent, then the steam to be condensed will contain 565 cal. per kg. (1 cal. per kg. = 1.8 B.t.u. per lb.). The temperature of the water of condensation will be about 30 deg. cent. and the number of calories lost per kilogram of steam condensed will be 565 — 30 or 535, with $P/p = 60$, which means a flow of cooling water equal to 60 times the flow of steam to be condensed. The heating of the cooling water will be 565/60 or 8.9 deg. cent., and the temperature of the cooling water as it leaves the condenser will be 15 + 8.9 or 23.9 deg. cent. There is therefore a margin of 29.4 — 23.9 or 5.5 deg. cent. between the temperature at the exit of the cooling water and the temperature of steam at the entry into the condenser.

The necessary condensation surface will be determined by this difference of temperature and by our knowledge concerning the coefficient of heat transmission that can be actually obtained.

In the discussion below the following notation is used.

P = hourly flow of cooling water in kg.
p = average flow of steam to be condensed in kg.
λ = number of calories to be taken away per kg. of steam to be condensed
F = heat-exchange surface of the condenser in sq. m. (1 sq. m. = 10.76 sq. ft.)
t_1 = temperature of cooling water at entry to the condenser in deg. cent.
t_2 = temperature of cooling water as it leaves the condenser in deg. cent.
t_v = temperature of steam in contact with the condenser tubes, deg. cent.
K = coefficient of transmission in cal. per sq. m. per hr. per deg. cent.

The conversion factors are not contained in the original article and have been inserted by the abstracter. The fundamental equation for the design of a surface condenser is

$$p\lambda = KF\delta_m \quad [1]$$

where δ_m is the average difference in temperature between the cold fluid and the hot fluid. Its value is given by the equation

$$\delta_m = \frac{t_2 - t_1}{\ln \frac{t_v - t_1}{t_v - t_2}} \quad [2]$$

On the other hand, the difference between the heat given up by the steam and the heat absorbed by the cooling water is expressed by the equation

$$p\lambda = P(t_2 - t_1) \quad [3]$$

Equations [1], [2], and [3] can be joined into a single formula giving the value of the coefficient of convection K in function of other variables, i.e.,

$$K = \frac{P}{F} \ln \frac{t_v - t_1}{t_v - t_2} \quad [4]$$

All of these formulas are in metric units. The value of the coefficients of transmission depends, of course, on the arrangement of the bundles of tubes, the velocity of flow of water in the tubes, and the condition of the tubes. It is also powerfully affected by the manner adopted for the extraction of the air from the condenser. One may assign to this coefficient limit values of from 2200 to 3500 cal. per hr. per sq. m. per deg. cent. If in the preceding example a value of 3120 for the coefficient K is adopted, it will be found that the condenser will provide the required vacuum while condensing 56.5 kg. of steam per sq. m. of tubular surface.

Effect of Increasing the Surface of the Condenser

It will be shown here that there is no great advantage in increasing the surface of the condenser if the cooling water is clean. Assume, for example, that the condenser in the instance cited above had its surface increased by 50 per cent, all other conditions remaining the same, including the coefficient of transmission. In that case the weight of steam condensed per square meter of the condenser surface will be 56.5/1.5 or 37.7 kg.

Going back to Equation [4] and substituting the new value of F, it will be found that t_v will become 27.2 deg. cent. corresponding to a vacuum of 96.47 per cent instead of 29.4 deg. cent. corresponding to a vacuum of 96 per cent. There will be a spread of only 3.3 deg. cent. (5.9 deg. fahr.) between t_v and t_2 which is difficult to maintain. Experience has shown that the coefficient of convection tends to decrease, particularly if the capacity of the air pump has not been increased, and the vacuum obtained will probably not be in excess of 96.25 per cent. If there is an increase in the surface of the condenser of 50 per cent there will be, therefore, under ordinary operating conditions, a gain in vacuum of 0.25 per cent. Under certain conditions the improvement in the vacuum will be still less, while the condenser will become much larger and more expensive.

Effect of Increasing the Flow of Cooling Water

A ratio of P/p of 60 for standard operation of the condenser has been assumed above. By increasing P by 25 per cent the ratio P/p may become 75. The heating of the cooling water will therefore be 535/75 or 7.1 deg. cent., producing an exit temperature of 22.1 deg. cent. Assuming that the coefficient of transmission has not changed, calculation will indicate a temperature of 28.7 deg. cent. at the wall of the condenser tubing, corresponding to a vacuum of 96.14 per cent. This vacuum can be obtained in regular operation. The increase, however, of 0.14 per cent is a small one and may not be worth while if the increase in power consumption by the cooling-water pump is not justified by the increasing economy in consumption of steam brought about by the increase in vacuum, which will be the case when the power plant is not working constantly at full load. With cooling water at 27 deg. cent. an increase in value of ratio of P/p from 60 to 75 will bring about an improvement in vacuum from 92.5 to 93.06, approximately. But as this temperature usually corresponds to the employment of refrigerated water and hence a very high total manometric head for the cooling water, the gains resulting from the improvement in vacuum will be partly negatived by the increase in power absorbed by the cooling-water circulation pump.

Better to fix these ideas, the author gives the diagrams shown in Fig. 3, from which will be found:

(1) The variation in vacuum corresponding to the ratio of operation as a function of P/p with circulating water varying from 15 deg. to 27 deg. This is based on the assumption that for a value of P/p of 60, a vacuum of 96 per cent will be obtained with circulating water at 15 deg. and 92.5 per cent with circulating water at 27 deg. cent.

(2) The decrease or increase in steam consumption in per cent per kilowatt-hour at the bus bar resulting from the variation of P/p with water at 15 deg. cent. at 27 deg. cent. Curve 1.

(3) Decrease or increase in percentages of power consumed by the cooling-water circulation pump again with water at 15 and 27 deg. cent. Curve 2.

(4) Gains or losses per useful kilowatt-hour resulting from the above variations. Curve 3.

It should be borne in mind that for loads less than the regular operating loads the gains due to the increase in the flow of cooling water will be smaller than when working at full load and may even turn into losses.

The curves just referred to have been plotted from the operation of single-flow turbines of 10,000 to 12,000 kw. capacity at 3000 r.p.m. and double-flow turbines of 20,000 to 25,000 kw.

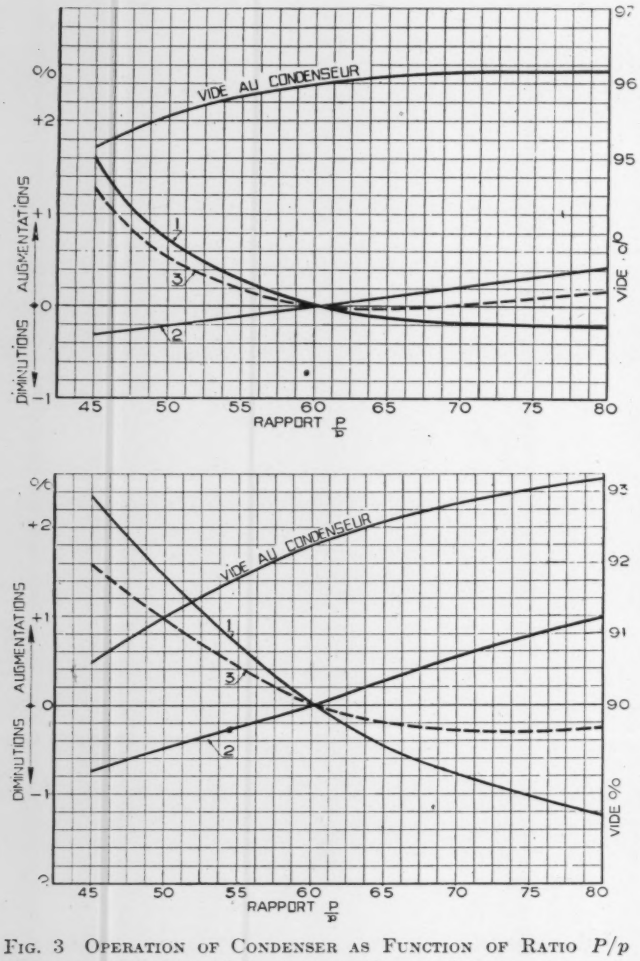

FIG. 3 OPERATION OF CONDENSER AS FUNCTION OF RATIO P/p (Abscissas: Ratio P/p; *vide* = vacuum; *vide au condenseur* = vacuum in the condenser; *A* (above) = cooling water at 15 deg. cent.; *B* (below) = cooling water at 27 deg. cent.)

It was assumed that the height of the manometric total rise was 6 m. (19.68 ft.) for water at 15 deg. cent. (59 deg. fahr.) and 14 m. (45.9 ft.) for water at 27 deg. cent. refrigerated in the latter case.

The efficiency of the centrifugal pumps was assumed to be 0.65 and the efficiency of their driving motors 0.85. From this it would appear that with P/p equal to 60, the power absorbed will be 1.24 per cent of the power of the prime mover with circulating water at 15 deg. cent. and 3 per cent with circulating water at 27 deg. cent.

Curves 1 show for a ratio of less than 60 increases in steam consumption following reduction in vacuum, and the reverse for P/p greater than 60.

Curves 2 show percentage of variation of power absorbed by cooling-water circulation pumps for a ratio of P/p equal to 60.

Curves 3 show increase or decrease of steam consumption in percentages per useful kilowatt-hour as a function of variation of P/p. It is found that with water at 15 deg. cent. when the ratio P/p is increased beyond 60, the curve of steam consumption remains very nearly horizontal for a considerable distance. With water at 27 deg. cent. there is a small gain. In practice this gain is found to be of limited extent only, due to the fact that the cooling of water in refrigerating plants is fairly inefficient when the flow of water is large and the difference of temperature small. The temperature of 27 deg. can be maintained only by increasing materially the dimensions of the condenser and hence its cost. In hot countries where available circulating water, even when taken from the sea or rivers, frequently attains temperatures as high as 30 deg. cent. (86 deg. fahr.) and over, there is every reason to increase the ratio P/p quite materially beyond 60.

It would appear from the above that at least for full-load operation there is no point in reducing the ratio P/p below 60, while an increase of this ratio produces within fairly large limits only a feeble effect on the economy per useful kilowatt-hour.

It may, however, have advantages of a different kind. For example, a faster flow of water may help to keep the condenser tubes cleaner and in this way improve the coefficient of heat transmission which, with all other things being equal, may permit a certain reduction in the necessary heat-exchanging surface.

When the condenser is operated at part loads it is usual to leave the output of the cooling-water circulation pump constant. In very large units where two cooling-water circulation pumps are run in parallel, there may be an advantage in cutting out one of the pumps when running at part load.

In general, the rule which fixes the necessary flow of cooling water at 60 times the weight of steam at full load, may be usefully employed as a basis of preliminary calculations. It is necessary, however, to remember that the weight of steam to be condensed per kilowatt-hour is a quantity varying with the efficiency of the turbine as well as with the cycle selected, which means pressure, temperature of steam, reheating conditions, etc. In very high-pressure modern central station, the weight of steam to be condensed may go as low as 3.5 kg. per kw-hr., while in a number of installations this figure is usually about 5 kg. per kw-hr., which means that the flow of water per kilowatt will vary from 0.200 cu. m. to 0.300 cu. m. (7.06 to 10.59 cu. ft.) (M. A. Risler in *Revue d'Electricité et de Mecanique*, no. 10, March-April, 1930, pp. X-37 to X-41, *p*)

Economic Developments in Turbine Generators in the United States

THE combining of large power systems in America into so-called superpower systems has brought about a demand for generators in capacities far beyond those which would probably have occurred under other conditions. These generators are intended to be used for the production of base load. Base-load stations are designed primarily to operate on the highest load factor which the system will permit. Every reasonable expenditure is allowed for in the design of such stations, if it will show increased economy in operation. In order, however, to keep the capital expenditure as low as possible, units of large capacity are installed, not only because they show a lower cost per kilowatt installed in the generating apparatus, but because the cost of switching gear and other power-controlling apparatus is reduced.

When it comes to the question of losses, it should be borne in mind that a large share of these losses appears as heat in the machinery itself and must be carried off by ventilation, which

costs money. As early as 1921 the author began to realize the fact that if the demand for larger generating units was to be met, a more complete knowledge of the source and magnitude of such losses was necessary. The difficulty of obtaining accurate determinations on the units of the size even then under construction was such that it would require years to accumulate the necessary data, and this would seriously retard the building of larger machines. It was finally decided to construct two little generators which would duplicate, in all essential details, the larger machines. These machines were so designed that rapid and inexpensive changes could be made in their construction and the effect upon the losses of the machine tested out. In this manner data were obtained in a relatively short space of time which nnder ordinary circumstances would have required years to accumulate. It is interesting to record that these little machines are still in use. The investigations carried out on these developmental machines led to the general adoption of non-magnetic steels for the so-called inactive parts at the heads of the machines, such as clamping flanges, fingers, etc.

As the result of the improvement effected by the changes mentioned above, as well as the improvement in ventilation, the efficiency of these units was increased from 96.5 or 97 per cent, to 98 per cent, and in the very largest units, to something like 98.5 per cent. This increase in efficiency is of far-reaching effect, for if the 100,000-kva. generator, described in the original article, had been built with the losses of the earlier machines, it would have required some 1600 kva. to ventilate it instead of only some 400 kw. which was actually required, which means that its ventilation would have been an extremely difficult matter and would probably have resulted in an actual reduction in the capacity of the unit.

Due to high rotational speed, the frictional loss, commonly called windage loss, becomes a serious factor in the efficiency of this type of unit. The problem of operating this class of apparatus in a medium of low density has claimed the attention of engineers for years. With the advent of the closed system of ventilation and surface coolers for extracting the heat from the cooling medium, the problem of the utilization of a gas lighter than air received a marked impetus. Hydrogen, due to its many favorable characteristics, has become accepted as the most desirable gas for this use. Hydrogen cooling is perfectly practicable, and its adoption will mark the next big step forward in the increase in efficiency of these large units.

Since hydrogen cooling results in a reduction in the so-called fixed losses, it becomes of increasing importance in machines intended for operation on rather poor load factors. There are a number of synchronous condensers in operation in America which are successfully employing hydrogen cooling. These have operated to the complete satisfaction of the purchaser. Adoption of this method of cooling in large generators will come when the invested capital shows a greater return than the same capital invested in other parts of the power station.

In connection with hydrogen cooling, the author discusses the whole subject of ventilation of large generators and tells of recent improvements. He refers to certain tests and says that the outstanding fact which these tests brought out was that, as far as ventilation was concerned, machines of any length could be built and, if properly designed, they could be as well ventilated as shorter machines. This conclusion was of far-reaching importance as it removed one of the factors which, up to this time, had, more than any other, impeded the progress in size of generating units. A second conclusion, of equal importance, was that, if properly designed, a machine of this rating could be built with losses, chargeable to windage, no greater than those of the 30,000-kw. generators referred to in the article. This machine employed external blowers instead of fans attached to the rotor, and this method of supplying the necessary ventilating air has become general on all of the larger units. Four high-speed, high-efficiency blowers are usually used. Such an installation provides a very flexible and economic operating arrangement, for, at the light loads, one or two blowers may be shut down with a consequent saving in power.

Within the past few years, interest has developed both in the United States and abroad in generators built for voltages higher than those which had been standard, namely, 13,200 to 14,000 volts. This trend has been for entirely different reasons. In England voltages as high as 33,000 have been advocated and one machine has been built at this voltage. The justification for such a voltage lies solely in the elimination of step-up transformers. In the United States the trend toward higher voltages has been brought about largely by the increase in generator capacities. and in an effort to minimize switching difficulties.

Distribution areas being so widely scattered in the United States, most of the power from the large stations today is sent out at potentials much higher than it would be possible with our present knowledge to build generators for. No attempt, therefore, has been made to adapt the generator voltage to the transmission potential. In cases where power is distributed at various potentials, say, 33,000, 66,000, and 132,000 volts, it usually works out cheaper to use step-up transformers for all three voltages than to wind the generator for 33 kilovolts and use step-up transformers for the two remaining voltages.

The result is that in America the building of large generators is confined to voltages which are most economical in station switching and bus-bar equipment. The introduction of the so-called double winding in large generators has also retarded, to some extent, the trend to higher voltages. (Paper presented at the World Power Conference, Berlin , 1930, by M. A. Savage, Turbine Generator Engineering Dept. of the General Electric Co. Abstracted from preliminary text obtained by courtesy of the General Electric Co., Schenectady, N. Y., illustrated, *kg*)

Recent and Possible Future Developments Affecting the Economics of Large-Steam-Turbine Practice in the United States

THE past five years has been a period of intense development and change in the power industry. The designs developed have shown the possibilities of producing cheaper power under the conditions prevailing in particular localities. There is, however, a wide difference in these conditions which permits several answers to the main question. One of the considerations governing new developments is that the useful life of a plant is determined by its obsolescence, as very few plants wear out, and a design which is too conservative will become obsolete sooner than would one of more radical character.

It is worth while to notice that the rapid progress which has been achieved in this country has been made in steps which have not been so large as to go beyond the possibility of producing reliable equipment. Each step, although large from some viewpoints, has not gone so much beyond experience as to lead to the incorporation of many untried elements in the vital parts of the construction. The result has been that all stations of new and untried designs have been successful commercially and are running in regular commercial service today.

SINGLE-CYLINDER VS. TWO- OR THREE-CYLINDER TURBINES

It is generally recognized that for the same quality of design a two- or three-cylinder turbine is a somewhat more efficient but a much more expensive machine than a single-cylinder turbine, and American plant designers prefer the latter type. This has forced the development of single-cylinder turbines to a very high degree of perfection in the United States. Up to capacities of

80,000 kw., where the pressure is less than 550 lb. per sq. in. and the temperature less than 750 deg. fahr., it is almost impossible to justify economically the more costly two- or three-cylinder designs. The company with which the writer is associated has concentrated upon the design of single-cylinder turbines which have extremely good efficiency over the useful load range. Being inherently simple, rugged, and low in cost, these have been very successful machines.

On the other hand, early attempts to build 600-lb. resuperheat machines with a single casing, while entirely successful from the operation standpoint, showed the desirability of dividing the turbine at the resuperheat point, which has been done on all succeeding designs. Both two- and three-cylinder tandem-compound and cross-compound machines have been constructed or are under construction. At present higher-pressure machines must of necessity be divided, often running the high-pressure turbine at double the low-pressure-turbine speed, that is, at 3600 r.p.m. with the low-pressure machine at 1800 r.p.m.

In connection with 1200-lb. and higher-pressure plants, there is somewhat of a difference in opinion as yet as to just how the high-pressure turbines should be arranged. The consensus of opinion, however, seems to be as follows: Where the 1200-lb. cycle is installed as an addition to a station already having low-pressure units and where it will have a high load factor, the new addition should have as many high-pressure non-condensing turbines as there are boilers, each turbine discharging through the resuperheater in its own boiler at constant pressure into the original low-pressure header to which the new low-pressure turbine is attached, the high-pressure flow being governed by the pressure requirements in the low-pressure header. On the other hand, in a new station many think that the high- and low-pressure turbine should be a cross or tandem compound with the entire governing of the unit on the high-pressure turbine and the cross-over pressure fluctuating with the load. The former arrangement is deemed by some to be a simpler one to operate and to be highly efficient as a base-load unit, whereas the latter may secure a cheaper and somewhat more economical unit where lower loads must be carried at times.

In a few cases where station conditions seem to warrant it, a new form of design called "vertical compounding" has been used. Two different arrangements are used. One is typified by the Jersey Central Power and Light Co. and the Pacific Gas and Electric Co. machines which have had the high-pressure turbine and generator mounted on top of the low-pressure generator. In this case the high-pressure turbine has been slightly under 25 per cent of the capacity of the entire unit, has operated upon 1200 lb. steam pressure, and has been arranged for boiler resuperheating back to the initial temperature between the units. These conditions are not, of course, necessary, but the high-pressure unit should be less than 25 per cent of the total capacity to permit the use of this arrangement. The other arrangement is typified by the Ford turbine in which the high- and low-pressure turbines are sufficiently close in output to permit the use of identical generators, in which case the two generators are mounted one on the other, and the high-pressure turbine is mounted on top of the low-pressure turbine. In the Ford installation the pressure is 1200 lb. per sq. in., with resuperheating by means of live steam to 550 deg. fahr. between the two units. This arrangement is quite easily adapted to other steam conditions wherever a cross-compound machine can be divided approximately equally. Special precautions have been taken to guard against differences in expansion between the supports of the upper turbine and generator, and to permit ease of dismantling the low-pressure machine.

The saving in space and foundations which such arrangements make is obvious. In the case of the Ford machine this 110,000-kw. unit is being placed in the same building, with the same spacing between units, as had previously been used for the 12,500-kw. unit which is being removed. In the Jersey Central unit the vertical-compound arrangement will permit the placing of three identical units in the space originally allotted to two cross-compound units of the same capacity.

The author devotes a good deal of attention to increase in capacity obtained from the low-pressure end. As more power is produced for less cost it becomes economical to increase the leaving loss somewhat. Two other factors tending toward the same result have been, first, the increasing number of sales of turbines of the southern states where vacua cannot be so high; and second, the desire for greater capacity within given building limitations. All of these factors have tended to increase the capacity which has been obtained from a given last-bucket annulus area.

The part of the paper dealing with the selection of the turbine unit and the steam conditions and the economics of choosing turbine capacity and turbine size cannot be considered here because of lack of space. Attention is called, however, to the fact that there is a distinction which must also be made between turbine capacity and turbine size. Two machines may each have the same capacity, say, 100,000 kw., but one may be larger, that is, have a larger and more liberal exhaust area, and hence, in general, a better economy. More material and labor may enter into its construction. It may frequently work out that the larger more economical machine will give the lower overall first cost of plant, due to better utilization of the investment in boilers, condensers, buildings, etc. The turbine uses not only fuel but the entire invested capital in the rest of the plant in producing power. In addition it is, of course, obvious that the more efficient machine will save fuel.

The author illustrates his general remarks by considering certain examples and typical installations for various pressures. This part is not suitable for abstracting.

As regards the present trend, the author believes that it is undoubtedly toward higher pressures. Resuperheating seems to be gaining ground and will probably remain as a permanent feature of a large proportion of new designs. The gain due to resuperheating is reduced by its combination with the regenerative feedwater-heating cycle and high feedwater temperatures.

Opinion is still divided as to the merits of resuperheating by means of high-pressure steam. With 600 lb. per sq. in. initial pressure its effect on the economy is rather slight, but its effect upon the operating life of the low-pressure blading is no doubt considerable by virtue of the drying of the steam. Further, the operational difficulties may be less than with boiler resuperheat, and it simplifies appreciably the piping design. Considering the thermal gain alone resulting, it is rather expensive.

The recent increases in operating steam temperatures from 750 deg. fahr. (the previously accepted upper practical limit) to 825 deg. fahr. and 850 deg. fahr. maximum, to which both boiler and turbine manufacturers in this country are now willing to go, may reduce the number of resuperheat installations somewhat. Resuperheating to the higher temperatures, however, will give practically the same relative gain in economy. There is a definite tendency, however, on the part of some plant designers to object to the complications brought about by resuperheating. This group will probably raise the pressure as the temperature limit is raised so as to limit to a reasonably small amount the moisture in the exhaust, and so get as good economy as possible from a relatively simple plant.

Formerly a turbine was simply a prime mover coupled to a steam pipe on one end, a condenser on the other, and driving a generator. Now it is an intimate and closely tied-in part of the power plant. The complexity of the modern high-pressure, resuperheating, and regenerative plant makes it necessary that the turbine should be considered and designed as a part of the entire

plant. What may be right for the turbine alone may not be best for the entire plant, and vice versa. The best solutions can only be obtained by taking all of the factors into consideration. This is being done by the engineers responsible for modern power-plant designs.

The author considers the relative economies of present and possible future steam cycles and notes the fact that because very high temperatures have been studied does not imply that it is felt that the industry is now in a position to try them on a commercial scale.

For ready reference the following figures are of interest to remember, all based upon regenerative cycles with feed pump taken into consideration:

1 Each 25-deg. fahr. increase in temperature gives about 1 per cent reduction in heat consumption.

2 A change from 400 lb. per sq. in., 750 deg. initial, non-resuperheat to 1250 lb. per sq. in., 750 deg. fahr. initial and resuperheat temperature gives about 12 to 13 per cent reduction in heat consumption.

3 A change of initial pressure from 1250 to 2500 lb. per sq. in. gives 3 per cent reduction in heat consumption with a one-resuperheat cycle and 3.7 per cent better with a two-resuperheat cycle.

4 A change of initial pressure from 2500 to 3500 lb. per sq. in. gives no gain with two resuperheatings to 850 and 900 deg. fahr., respectively, and a further change to 5000 lb. per sq. in. shows a loss.

5 The exact thermal gain due to the first resuperheating back to the initial temperature is rather difficult to evaluate exactly because of the uncertainty as to the exact amount of moisture extraction in the high-pressure non-resuperheat cycle. The gain is probably from 3 to 4½ per cent.

6 Two resuperheatings with five to six feedwater heaters to 460 deg. fahr. gives 2.25 per cent gain at 1250 lb. per sq. in., and 3 per cent gain at 2500 lb. per sq. in. as compared to one resuperheating.

The average capacity of the turbines built each year will probably continue to increase. Such an increase will probably bring both reduced station first cost and better economy. The maximum size of single units will continue to increase and may reach 200,000 kw. for a single-shaft, 1800 r.p.m., hydrogen-cooled-generator unit. Such a unit will have a very favorable first cost and economy. Two generator, cross-compound machines will be very much in favor where length is a limitation. It is yet too early to predict whether or not the three-cylinder, triple-compound turbine for very large sizes will be used extensively. The complexity of control works against it as compared to the simpler two-cylinder, cross-compound, vertical-compound, or tandem-compound unit. It is also too early to judge the future use of the vertical compound, but if the operating experience bears out present expectations, it is safe to say that the economies in space and foundation which it permits will make it an important type.

The use of one high-pressure, 3000- or 3600-r.p.m., back-pressure turbine for each high-pressure boiler, exhausting at fixed back pressure into the lower-pressure headers feeding the 200- or 400-lb. turbines, is likewise a design which must be further compared in actual operation with the tandem- or cross-compound arrangement with variable cross-over pressure before a final judgment is made. With an increase in pressure to 2400 lb. per sq. in., it may have very definite advantages.

Steam conditions will probably continue to change, with steadily more efficient conditions being used. The calculations given in a preceding part of the complete paper seem to indicate quite clearly that with present temperature limitations, 2500 lb. steam pressure is nearly the economical limit. If this high pressure can be combined with 1000 deg. fahr. initial temperature and six or seven stages of feedwater heating, without resuperheating, it will be possible to produce a unit with a very high efficiency and great simplicity. In the case of large cross-compound units with three or four cylinders and two or more boilers per turbine, two resuperheats may prove practical; that is, where divisions would be made in the turbine for other reasons as well, and where the two resuperheaters can be put into separate boilers.

To sum it up, there is no single trend. The power-plant art is yet in a state of flux. It would be unwise to try to make a definite prediction as to what the future power plant will be like. It seems certain, however, that with the large number of able minds throughout the world working on it in the future as they have been doing in the past, and if cheap fuel resources continue to be available, the net cost of power to the electrical industry will continue to be reduced. (Paper presented at the World Power Conference, Berlin, 1930, by G. B. Warren, Turbine Engineering Department of the General Electric Co., illustrated. Abstracted from preliminary release, courtesy of the General Eelctric Co., Schenectady, N. Y., *dt*)

TESTING AND MEASUREMENTS

Tests of Cold-Drawn Bridge Wire

THIS article describes tests carried out at Lehigh University on cold-drawn bridge wire which replaced the heat-treated wire that failed at the Ambassador Bridge, Detroit, and the Mt. Hope Bridge, Providence, R. I. Of practical interest are the creep tests, i.e., increase in strain under a constant load. This was studied at loads up to 50 per cent greater than the bridge design stress.

The averages for the two-week tests indicated that the largest creep occurred with the specimens which were bent around the sheave in the reverse direction of the coiling curve, the next largest with those tested straight, and the least with those tested in the direction of the coiling curve. The averages for the two-month tests indicated, on the other hand, that the largest creep occurred with those tested straight, the next largest with those bent in the direction of the natural coiling curve, and the least with those bent in the reverse direction. When the values of the two-week and the two-month tests were averaged, those tested straight showed somewhat the larger creep, and there was no great difference between those bent in the natural direction of the coiling curve and those bent in the reverse direction. The average creep was 280, 215, and 224 millionths for the specimens tested straight, bent in the natural direction, and reverse direction. With this difference in the results for the two-week and the two-month tests, it seems fair to conclude that there was little difference in so far as creep is concerned between the straight specimens and those bent in either direction.

It was also concluded that the tensile strength was not affected by the duration of test or by testing the wires around the sheaves.

Effects of mishandling have also been studied as well as tests made to study the seating and wedging action of wires laid over strand shoes, and these showed that the effect of variation in seating conditions on the strength of the wire is negligible.

To investigate the effect of the bending stresses developed by coiling the wire to a diameter of 19½ in. during a prolonged period of time, wires 300 to 400 ft. long have been so coiled and stored for nearly a year with no breakage or other visual defects noted.

Deep etchings and metallographic tests showed the wire to be of average commercial structure and uniform hardness, and while not entirely free from inclusions of slag, it was fully sufficient to meet the exactions imposed upon it by the tests. (Leon S. Moisseiff, Consulting Engr., New York City, in *Engineering News-Record*, vol. 105, no. 3, July 17, 1930, pp. 93–95, 3 figs., *e*)

Engineering and Industrial Standardization

International Standards Association Conferences in Paris

A SERIES of technical conferences was held in Paris, May, 1930, under the auspices of the International Standards Association (I.S.A.), a federation of eighteen national standardizing bodies including the American Standards Association (A.S.A.). This body was represented by John Gaillard, mechanical engineer on the A.S.A. staff. The following is a brief summary of his report to the A.S.A. which will be published in the September issue of the A.S.A. Bulletin. Following the series of technical conferences, a conference of secretaries of national bodies, a meeting of the I.S.A. Council, and a Plenary Assembly were held.

The technical conferences dealt with the following subjects: technical drawings; twist drills and other small tools; test pressures for the acceptance of new stationary steam boilers; wrench openings; rivets; size grading, and sampling and analysis of coal; traffic signals; petroleum products; and fluid meters.

Technical Drawings

It was recommended that an I.S.A. technical committee be appointed to deal with this project, the work being divided into three groups of subjects on the basis of their urgency, as follows:

Group I: Sizes of drawings and scales of reduction and enlargement; finish marks; indication of tolerances and fits; symbols for bolts and rivets; representation of welds; property and copyright stamp.

Group II: Arrangement of views and sections; representation of screw threads; cross-hatching of sections; section lines and planes, and methods of indicating dimensions; tapers and slopes (also the taper of shafting keys); symbols for springs, gears, etc.

Group III: Lettering; type, thickness, and use of lines; method of folding drawings; designation of different kinds of drawings; graphic presentation; designations of materials, and their abbreviations; model working drawing.

Mr. Gaillard reported on the progress of work of the Sectional Committee on Drawings and Drafting-Room Practice, sponsored by the A.S.M.E. and the S.P.E.E.

All Continental countries, with the exception of Holland, use first-angle projection. The representatives of Holland and U. S. were invited to submit a joint report on the use of the third-angle projection. A memorandum on this subject has been sent to the Dutch body by the A.S.A. office. The Swiss national body will act as secretariat for Group I, while the Austrian and French bodies will share the secretariat for Groups II and III.

Twist Drills and Other Small Tools

This conference resulted in a recommendation that work be started under I.S.A. auspices on several subjects classified in groups on the basis of their urgency, as follows:

Group I: Twist drills; machine tapers; squares for tool shanks; sections and nomenclature of cutting tools; general nomenclature of tools.

Group II: Threading tools; reamers; milling cutters.

The work accomplished by and under way in the A.S.A. Sectional Committee on Small Tools and Machine-Tool Elements was reported to the conference, especially that on milling cutters and cut and ground thread taps (both approved since as American Standards), and on sizes of twist drills and machine tapers, still under consideration. The general secretariat was assigned to the French body, while the German body was invited to handle machine tapers (both metric and inch), and the Swiss body sections and nomenclature of cutting tools.

Test Pressures for New Stationary Steam Boilers

It appeared that there was a general tendency on the Continent to lower the test pressures for new boilers, as it has been found that a relatively high test pressure might damage the boiler in a way that could not be detected immediately. Very minute cracks, invisible to the naked eye, might be caused in the boiler plates, starting out from the rivet holes, and result in the destruction of the boiler when in actual operation. More attention was given to the yield-point value than formerly, when tensile strength was considered the most important factor.

The Czechoslovakian body, which holds the secretariat for the international work, had proposed a test-pressure formula as one that might be internationally acceptable.

Wrench Openings

The secretariat, held by the Swedish body, had worked out a proposal of a new series of wrench openings which were smaller than those now adopted as standard in most of the Continental countries. This proposal had been submitted shortly before the Paris conference so that it was impossible to consult in advance with the A.S.A. Sectional Committee on Bolt, Nut, and Rivet Proportions.

During the discussion of this proposal in Paris it appeared that the objection of the Continental bodies to a change in wrench openings was based on the fact that relatively large wrench openings had already been widely adopted, on the Continent, rather than on technical exceptions to smaller sizes. The president of the I.S.A. explained how the larger European sizes were due to the fact that the term "U.S. Standard" had been understood on the Continent about ten years ago to refer to a standard actually adopted in a national way in the U.S. At the time when it had been discovered that the Americans were planning to adopt smaller wrench openings, the larger sizes had already been adopted in Germany and several other countries. But for this misunderstanding, an international standard comprising smaller wrench openings might now have been arrived at.

In connection with the trend of the discussions, Mr. Gaillard laid before the Conference the two following questions:

1 Do the small American sizes of heads and nuts, or sizes close to these, appear to be acceptable to the other delegates, considered from the *technical* point of view (that is, leaving aside the difficulty of making a transition from the existing standard to a new standard, whatever that new standard may be)?

2 Are round millimeter sizes essential for a new series of wrench openings, in the opinion of the delegates?

Both questions were extensively discussed, with the result that the delegates of all countries represented, except one, agreed that the American wrench openings appeared to be acceptable from the technical point of view. The exception was the Swiss secretary, who said that the manufacturers in his country objected to the smaller bearing area of the smaller heads and nuts. With regard to question 2, there was unanimous agreement that inch-size wrench openings expressed in fractions of millimeters

would be acceptable for the sake of international uniformity.

As a result of the Conference the Swedish secretariat was requested to reconsider its proposal on the basis of the discussions.

RIVETS

The Dutch body, secretariat for the international work on this subject, had submitted a proposal covering the method of measuring the rivet diameter; series of sizes of small and large rivets (below and above 10 mm.); tolerances on diameter; and angle of countersunk head. The conference found that the thickness of a rivet should be measured, independently of its size, at a distance of 5 mm. below the head (of a straight-shank rivet) or below the base of the taper neck of countersunk head.

Standardization of tolerances of rivets below 10 mm. was not considered as necessary. For rivets of 10 mm. and upward, the tolerances proposed were considered as somewhat ample. The conference recommended that the Dutch body revise the values in the downward direction.

The series of small rivets tentatively recommended was 1.0, 1.2, 1.4, 1.7, 2.0, 2.3, 2.6, 3.0, 3.5, 4.0, 5.0, 6.0, 7.0, 8.0, and 9.0 mm; and of large rivets, 10, 13, 16, 19, 22, 25, 28, 31, 34, and 37 mm.

A decision on countersunk angles was postponed, the diversity of combinations between angles on the one hand, and type, size, and use of rivets on the other hand, being too great to arrive at a decision at the Conference.

COAL

Classification of coal on the basis of grain size (size grading), methods of sampling and analysis of coal, and classification of coal on the basis of its physical and chemical properties were the items discussed. It was recommended that the work be started under I.S.A. auspices, first on size grading and methods of sampling and analysis, classification of coal possibly to be taken up later.

Mr. Gaillard reported on the progress of the American work, among other things, in the A.S.A. Sectional Committee on Classification of Coal.

NOMENCLATURE AND METHODS OF TEST FOR PETROLEUM PRODUCTS

It was unanimously recommended that this subject be taken up by an I.S.A. technical committee, and that the secretariat for the work be assigned to the American group. A minority of countries expressed a desire that quality specifications for petroleum products be also taken up under I.S.A. auspices, as proposed some time ago by the Russian body. Mr. Gaillard explained the standpoint of the American groups interested, to the effect that they did not consider the time ripe for standardization of petroleum products, but were in favor of discussing methods of test and nomenclature in an international manner.

FLUID METERS

The proposal to have an informal discussion of this subject at Paris reached the A.S.A. office very shortly before the Paris Conference, so that no correspondence with the A.S.M.E. Special Research Committee on Fluid Meters was possible. Mr. Gaillard reported to the Conference on the status of the work in this committee.

The Conference urged that the work be taken up, attention being called to a memorandum submitted at a meeting by Dr. Witte of the German delegation as a possible working basis for the international work.

PLENARY ASSEMBLY

The principal decisions taken at this meeting were with regard to rotation of membership in the I.S.A. Council. It was decided that on January 1, 1931, Germany would retire on behalf of the United States. This means that before that date the A.S.A. is invited to appoint a member of the I.S.A. Council.

The central office of the I.S.A. will be moved from Zurich, Switzerland, to Basle, Switzerland. The budget of the I.S.A. office will remain $8000 for the present year and 1931, voluntary contributions being asked as the budget should preferably be increased. Professor List, Chairman, Czechoslovakian national body, would draft a new scheme of distributing the financial support between the national bodies. This scheme will apply to the calendar year 1932 if approved by the Plenary Assembly. Sir Richard Glazebrook, who represented the B.E.S.A. on the Committee of Seven in the preliminary stage of the I.S.A. before it was formally established, was appointed by acclamation Honorary President because of valuable services rendered in bringing about the formation of the I.S.A.

Correspondence

Transverse Tests on Cast Iron

TO THE EDITOR:

It is worthy of note that reports of transverse tests on cast iron usually ignore two facts which might simplify the mysteries of transverse strength.

The first is that when a test bar is pulled and then released, the deformation consists of two distinct parts, (*a*) elastic deformation and (*b*) plastic yield. E. C. de Segundo (see "Experiments on the Strain in the Outer Layers of Cast-Iron and Steel Beams," Minutes of Proceedings, Institution of Civil Engineers (England), vol. 98, 1888–89) separated the two parts. C. Bach also determined this fact quite conclusively at much the same time. (See page 36 of "Elastizität und Festigkeit," by C. Bach and R. Baumann, Julius Springer, Berlin, 9th edition, 1924.)

The second fact, or perhaps more correctly, hypothesis, capable of theoretical proof and easy to prove or disprove in practice by test, is that when an elastic beam of rectangular cross-section is bent the resulting elastic stress-distribution across a transverse section is composed of parts of the stress-strain curves of the material in tension and compression, respectively.

As a corollary, if Hooke's Law is to remain the criterion of an elastic material it will be necessary to translate it by "Stress is some function of the strain," instead of that stress is a simple proportion to the strain. This also follows on the fact that cast iron and many other common engineering materials which are elastic (within limits) according to the real meaning of the term have no straight parts in their stress-strain curves.

Conceptions about the joint elasticity and plasticity, apparently possessed by every common material, which might usefully be further explored, are:

(1) Materials, like machines, possess some backlash. In the case of elastic materials the "backlash" or plastic yield can be removed temporarily by successive loading and unloading, to enable the elastic properties to be studied.

(2) Many materials, e.g., mild steel, are elastic up to a certain stage and are thereafter plastic. There is also some removable plastic yield during the elastic stage.

(3) Materials such as concrete and the cast metals are elastic nearly up to their ultimate strength although they possess also some backlash or plastic yield which requires removing.

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MECHANICAL ENGINEERING

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Paris to New York by Air

THE FLIGHT of Dieudonné Coste and Maurice Bellonte is more than a spectacular performance. Since Lindbergh's flight in the opposite direction it could have been safely predicted that the flight from Paris to New York would be achieved in the near future. True, the direction of the prevailing winds was known to be less favorable for flying east to west than west to east, but this meant simply an additional expenditure of fuel, and it was obvious that with the improvement of airplanes which is constantly going on, enough saving in fuel consumption could be secured to permit fliers fortunate enough to encounter reasonably good weather to make the crossing in the opposite direction. The German-Irish crew of two years ago very nearly did it, and it was clear that some one else would accomplish it soon.

The Coste-Bellonte flight is, however, more than the result of a combination of improvement in airplanes with good luck. It is an old saying that "the Lord takes care of those who take care of themselves," and this is applicable to the French flight across the Atlantic. Unlike many other attempts, it was not done on the spur of the moment, with the first equipment that could be secured or donated for the purpose. In the first place, Coste and Bellonte held records for several long-distance flights, which means that the supreme skill and physical endurance required for such performances were amply present in their case. What is more, their experience on flights across the South Atlantic and the vast stretches of the Siberian and Chinese steppes gave them a thorough knowledge of the factors that have to be provided for to make long-distance flights a success.

It took Coste and Bellonte three years to get ready for the flight which they finally successfully achieved. They were willing to sacrifice years of work to avoid taking unreasonable chances, as they proved last year when they turned back after passing a goodly section of the way across the ocean because excessively strong head winds were cutting down their fuel supply to a dangerous extent. A Scandinavian saga tells that heroes play dice with the gods when they attempt their deeds, but that the dice of the gods are likely to be loaded. If one may be permitted to use a colloquial phrase, flying the Atlantic is no game for greenhorns.

As regards transatlantic communication by plane, however, the Coste-Bellonte flight has merely confirmed the general impression among engineers that it is not feasible with airplanes of the present type, unless indeed some means of refueling during flight somewhere in mid-ocean can be devised.

The Bantam Automobile

THE INTRODUCTION into the American market of the American-built British Austin automobile and the projected building of the French Mathis car by an organization controlled by W. C. Durant, make it of interest to examine the conditions, favorable and otherwise, that may affect the success of this type of automobile in America.

In Europe the existence of the Bantam car is clearly justified. People there as a rule are not willing to spend much on automobiles, the price of which generally is very much higher for the same size than it is in America. The Bantam automobile is therefore a car for the moderately well-to-do person, the kind of man that in the United States would buy the least expensive car made here. The very high tax on automobiles makes the large car still less attractive in Europe, while the cost of fuel, which is several times that in the United States, places an additional handicap on the heavier car.

In America conditions are supposed to be quite different. Taxation is low and the difference in the matter of cost of license plates is only a few dollars. Fuel is so cheap that except for those who cover a very large mileage the difference between 25 miles and 40 miles per gallon is not in itself a matter of prime importance. The Bantam car has an advantage when it comes to the cost of tires, but with the present mileage of tires, the difference is only a small one. Even when it comes to initial cost the Bantam is not to be had for much less money than would purchase low-price cars of standard make.

Nevertheless there is little doubt but that the Bantam car is here in America to stay. For a number of purposes it has a decided advantage. In the first place, its low consumption of gasoline, low cost of tires, small size, and the small amount of storage space required make it an ideal vehicle for city delivery service where the motorcycle with side car has been tried and often found unsatisfactory as well as dangerous. When the car has to be housed on store premises the small size of the Bantam is a decided advantage, and it does not seem wasteful and unreasonable to send so small a car to deliver a couple of hats or an order of jewelry.

America is more and more becoming a country where the average well-to-do family has more than one automobile, or would like to have a second car provided it could be stored conveniently. Here again the small size of the Bantam car becomes a vital advantage. A car that will take the lady of the house shopping, is big enough for the young hopeful and his girl, and actually can be stored without moving the house into the middle of the street, is bound to find admirers and purchasers.

The vital element to the success of the Bantam car will be the degree of its mechanical excellence. Some twenty years ago there was a wave of enthusiasm in connection with the manufacture

of the so-called cycle car, which in size approached the present Bantam car. This wave subsided as fast as it arose, leaving several stranded plants behind, largely because the cycle car proved to be mechanically poor and unable to give proper satisfaction to its users. Today, however, the Bantam car is built by well-organized and well-financed companies with ample experience abroad in the manufacture of this type of vehicle, and should not suffer from this defect.

Commercial Possibilities of the Airship

AN INTERESTING editorial under this title dealing with the British airships *R-100* and *R-101* was published in the August 15, 1930, issue of *The Engineer*. The conclusion to which the editorial comes is that neither the general popular impression as to the poor prospects of earnings of airships nor the super-optimistic statements of the advocates of commercial airships (as, for example, Sir Dennistoun Burney, in the London *Financial Times*) which promise a dividend of 50 per cent on the invested capital have sufficient support in facts. The analysis of the *R-100* and the *Mauretania* made by the author of the editorial would seem to indicate that under certain assumptions it may be considered that neither the initial cost nor the apparent cost of manufacture of the airship is excessive when compared with similar items for the big transatlantic vessels. In this connection some figures are quoted which are not generally known in this country. In the House of Lords last June, Lord Thomson stated that the *R-100* and *R-101* had cost together £894,000, exclusive of the money spent on research sheds, towers, and the organization of ground and metallurgical services. It is safe, to say, of course, that the two vessels could be duplicated today at a considerably lower cost. The two sheds and the tower at Cardington, the towers at St. Hubert and Ismailia, and the provisions of the ground and metallurgical services for the two vessels represent a further expenditure of £1,101,000. At five per cent per annum for interest the traffic would have to provide £55,050 each year to meet the terminal charges.

In all of the calculations of commercial possibilities of airships certain assumptions are made silently or explicitly, and it is well to consider what these assumptions are. In the first place, it is assumed that regular operation of the airships is possible, which means that these vessels can operate on a fixed schedule of voyages both summer and winter. The fact that every transatlantic voyage undertaken by lighter-than-air craft has been successfully accomplished and the further fact of the voyage around the world of the *Graf Zeppelin* bear clear witness to the high ability of modern airships to handle weather. At the same time it must be remembered that the *Graf Zeppelin* turned back once after passing Spain on one of its trips because of motor trouble; that on another trip the *Graf Zeppelin* ripped a fin, and was in a condition of considerable peril; and that the *R-100* on its flight from England to Canada likewise ripped a fin. All of these may be considered as minor mishaps, but they indicate the comparatively easy vulnerability of at least some features of operation of airships, and would lead one to be conservative in the matter of prediction as to what will happen, for example, when airships are exposed to the storms of the Atlantic during the fall, winter, and spring seasons. Even if the ships are not wrecked, but, after each stormy passage, repairs are required, the cost of maintenance may rapidly run into figures large enough to consume what would otherwise have been attractive profits of operation. This is not written in a critical spirit, but merely as a note of caution and to indicate the necessity of obtaining as quickly as possible reliable data as to the cost of operation of an airship in regular service over, say, a period of twelve months, including full and detailed data as to the cost of maintenance and repairs. It is all the more important to have these figures, as it is only on the basis of such information that the very important question of the cost of insurance for the passengers and ships can be determined.

British Steel Through American Eyes

IT IS becoming customary abroad when economic ills become acute to call in an American doctor. Country after country has resorted professionally to Professor Kemmerer's advice on monetary ills. The work of Millspaugh in Persia, Dawes and Young in the settlement of German debts, and recently Budd's survey on Russian railroads are but a few more examples of the same trend.

The latest of such American attempts to bring order into a chaotic and disorganized foreign major industry is represented by a report made to British steel makers by J. L. Replogle, well known in this field in his own country. There are certain phases of this report which are well worth attention. First is the fact that a man of wide interests in the steel industry of his own country as is Mr. Replogle should consent to give advice to those who are practically competitors of ours. Still more significant is the fact that Mr. Replogle undertook this work only after having discussed it with the leading steel makers in the United States, who told him to go ahead, as any improvement in British steel industry would result in a general improvement in English business and consequently increase the trade between the two countries. This is a generous and unusually far-sighted attitude on the part of American industry.

The ills that Mr. Replogle discovered have been well known in a general way for a long time. Basically poor management exists, because of concentration of ownership of plants in a few families, with the result that managers, like kings of old, are born to their jobs instead of having to fight their way up as is the case in America. The second weak point of the industry is the prevalence of small plants making steel in a small way. From Mr. Replogle's figures, for example, it would appear that the average output per British blast furnace is only about 20 per cent of that in the United States. Mr. Replogle recommends concentration of production in larger plants with particular attention to intermediate materials such as blooms, billets, bars, etc., which are today imported into England in unnecessarily large quantities.

It would be difficult to say offhand if such a program can be put through. Mr. Replogle is not the first, of course, to realize that steel can be made cheaper in large specialized plants, each making only one group of products, than in a number of small plants making everything under the sun. In America this idea was laid at the foundation of the organization of the United States Steel Corporation, and more than one Britisher has realized that the same principle would improve the state of affairs in England. There is, however, one condition in the British Isles with which Americans do not have to contend and that is the lack of land for big plants. Acreage is plentiful for industrial sites in this country and comparatively cheap. In England where the land in the neighborhood of larger towns and on the seaboard is largely held by estates, the problem of finding a piece of ground that will combine accessibility to land and water transportation with the space necessary for a steel mill with a production of, say, one and a half million tons a year, is a truly baffling one. It has even been suggested that special laws along the lines of condemnation of property for public purposes might be passed to meet this situation, but so far nothing in this direction has been done. As regards the elimination of the remnants of the feudal system of control of the steel industry, this is already under way. The way to its accomplishments is pointed out

by such combinations as those involving the Vickers Co., Armstrong-Whitworth & Co., and Cammell, Laird & Co.

Business Cycles and the Present Depression

ACCORDING to the classical theory of business cycles, their occurrence is largely due to an over-swing of what is at first a regular development of business. As business develops here and there, estimates of prospective demand are made rather optimistically. Plants are therefore built and production is increased beyond buying capacity. This brings about an oversupply of goods, a fall of prices, and a business collapse, followed by a period of dull years during which conservatism prevails, but at the end of which enough capital and buying demand accumulates to bring about another cycle of good times, in turn to be followed by a new period of over-expansion. The fact that the average business cycle takes about ten years, and the further fact that the major weather changes also follow a cycle of about ten years, has led some economists to connect the two, with the further claim that good and bad times in agriculture more or less directly cause the changes generally known as the business cycle.

The conditions which brought about the present depression in American business appear upon analysis to be somewhat different from those leading to the closing dramatic events of the business cycle of standard economists, and they are of particular interest to the engineer because, probably for the first time in the history of economics, he may be said to have been partly responsible for what has happened.

A tremendous amount of technical development has been going on in all industries during the last ten years, and at a constantly accelerating pace. Machines have been reconstructed and changes made which have increased production enormously. The steel industry is a good example. Several years ago the American Iron and Steel Institute made a survey of the steel industry in this country and found that, while its capacity was not too far ahead of the consumption capacity of the country, the existing plants could produce a good deal more than the country required. As long as the excess of production capacity over consumption capacity remains within reasonable bounds (and unfortunately no one knows what these reasonable bounds are) it is merely an insurance against excessive rise of price should the demand suddenly increase for some reason or other, an insurance which proved to be of such enormous value to this country during the war years.

When, however, the excess of capacity becomes too great, trouble is bound to result. Now what has happened in the steel industry since the Iron and Steel Institute discovered an already excessive capacity? In the first place, a number of new large plants have been built. Detroit, which a few years ago was negligible as a center of steel production, has acquired an important significance, and another large center of production is growing up in Texas. The production on the Pacific Coast has increased by leaps and bounds. The already vast plant at Gary has had two enormous additions, one in the way of sheet manufacture and the other of pipe. Close to $100,000,000 has been spent in the installation of continuous sheet mills, while another couple of score of millions of dollars has been put into pipe and tube mills and their auxiliaries. Everywhere the mills have been equipped with new auxiliaries permitting a more rapid output, faster handling of goods, or shorter periods of turnover of materials, with the result that should another investigation of the production capacity of the country be made today, it would probably be found that the actual productivity has increased in the last ten years not less than 60 per cent.

What has happened in steel has also happened in many other lines of business. Consumption, though increasing with the wealth of the country and the growth of the population, has not grown with the increase of production in basic lines of industry, and a substantial share of the consumption has been drawn from other fields. At the end of the war period there was a great shortage of housing facilities, which brought on an era of intensive construction, primarily of the urban type, with consequent great demands on such basic industries as steel, brick, lumber, etc. This shortage, however, has been practically covered now, and people, not having to build houses, are buying radios, are installing miniature golf links at the rate of $100,000,000 a year, and are preparing to spend another $100,000,000 in the next year or so on television sets as soon as the manufacturers have perfected them commercially. There is no depression just now in the miniature-golf-link business, and there will be none in the television business, which indicates that such depression as there is is not due to bad times and consequent inability of the people to buy goods, but to the fact that there is an over production in basic commodities. It is, however, in the production of these basic commodities that the greatest number of people are employed, with the result that any slowing down in these lines is immediately reflected in the form of widespread unemployment, falling stock-exchange prices, and all the aspects of panic conditions, even when a panic itself is absent.

We therefore see the paradox of a rich population willing to spend millions of dollars on unessential luxuries, concurrent with a business depression in fundamental lines. Whether this is a temporary condition or one of a more or less permanent nature remains to be seen.

The Berlin Steam Table Conference

THE Second International Steam Table Conference was opened on June 23, 1930, in the Ludwig-Loewe House, Berlin, Germany, by Prof. Dr. Ing. Matschoss, Director of the Verein deutscher Ingenieure. The following delegates were present:

American Delegates: Dr. H. N. Davis; Dr. H. C. Dickinson; Prof. J. H. Keenan; Dr. F. G. Keyes; Geo. A. Orrok; Dr. N. S. Osborne; C. B. LePage.

German Delegates: Dipl. Ing. W. Fritz; Dr. Hausen; Dr. Henning; Dipl. Ing. Höhner; Prof. Dr. M. Jakob; Geh. Prof. Dr. Knoblauch; Dr. Koch; Prof. Dr. Kraft; Geh. Prof. Dr. Mollier; Geh. Prof. Dr. Nernst.

English Delegates: G. S. Callendar; J. P. Chittenden; R. Dowson; A. C. Egerton, F. R. S.; H. L. Guy; D. V. Onslow; B. Pochobradsky; I. V. Robinson; F. Samuelson; G. Stoney, F. R. S.

Czechoslovakian Delegates: Dr. Havliček; Professor Miskovsky.

Swedish Delegate: I. V. Blomquist.

Swiss Delegate: Prof. Dr. Eichelberg.

Present by Invitation: Dr. A. M. Greene, Jr.; Wm. L. Abbott; Ely C. Hutchinson.

Geheimrat Prof. Dr. Nernst, whose work in the kinetic theory of gases and in the application of thermodynamics to chemistry is internationally known, was unanimously chosen chairman. After the delegates had introduced themselves individually to the Conference, several of the experimenters present gave brief surveys of the progress made since the London meeting (1929).

The chairman then appointed a working committee consisting of at least one member of each national delegation. This committee was authorized to revise the skeleton table of the London Conference and to prepare a complete report for presentation to a later plenary session of the Conference.

Before adjournment Mr. A. C. Egerton, F. R. S., read a memoir on Prof. H. L. Callendar which he had prepared for the Conference. He said in part:

> Callendar's life work, as one looks back on it, is like that of other pioneers, in that it has a consistency and forms of itself a kind of living growth. Just as an individual is unique, such lifework is unique; it has individuality. Callendar's work grew from the resistance

thermometer, through calorimetric measurements, to embrace the whole thermodynamic properties of steam. It was a growth gathering experience as it progressed from stage to stage, every previous stage being necessary for the building up of the next. It is unnecessary here to dilate on the usefulness of such a life's work—every scientist and engineer knows that on such work and such men the future of civilization rests.

Callendar never spared himself, he worked persistently, indefatigably, designing, constructing with his own hands, making his own observations; all his work bears the hall mark of his own experimental skill. Callendar was indeed an artist and through accuracy he has left us a permanent structure of his life's work.

Professor Keenan called the attention of the Conference to another serious loss which the field of steam research has sustained. In October, 1929, Prof. G. A. Goodenough died. Since the publication in 1915 of his masterly study of the properties of steam and ammonia he had been engaged in numerous researches connected with internal-combustion engines and steam turbines. In all that time he was a sympathetic and helpful observer of research on the properties of steam.

It is interesting to note that there were two more nations represented at Berlin than at London. Sweden was represented by Mr. I. V. Blomquist who did some of the earliest experimental work on the total heat of saturated steam at pressures up to 1400 lb. per sq. in. Switzerland was represented by Prof. Dr. Eichelberg who has succeeded Dr. Stodola in the field of steam-power engineering at the Polytechnikum in Zurich. Dr. Eichelberg was the author of the equations of the properties of steam which have been employed by Dr. Stodola in the preparation of the steam charts in his recent editions of "Steam and Gas Turbines."

The working committee met Tuesday morning, June 24, and unanimously elected as its chairman Mr. I. V. Robinson, who had so ably directed the work of a similar committee at London. The experience gained at London made for a ready understanding of the points of view of the several delegations and facilitated the work of the committee. In two and a half days of concentrated activity the skeleton table was revised in detail, with careful consideration of each point, and a complete report drafted.

Material progress resulted from the committee's labors. The general policies adopted at London were adhered to and considerably strengthened. Each delegate came to Berlin with a more thorough understanding of the significance of those policies, and the fact that they are retained is evidence that the London Conference builded well. Much that was done in London in haste was revised or reestablished in the light of a year's accumulated evidence.

There were, of course, differences of opinion—without them there would have been no international conferences. But the good-fellowship established at London and the more thorough understanding of other opinions which followed from the discussions of the year before, made the adjustment of these differences keenly interesting rather than disputatious.

The report of the working committee was presented and accepted in full at a plenary meeting on Thursday, June 26. At the same meeting Dr. Egerton and Dr. Keyes presented some interesting details of the research work which they had in progress, and provision was made for shifting the secretariat before each conference to the delegates of the host nation.

One left Berlin with impressions of hours of shirtsleeve labor under the cheerful but unrelenting direction of Chairman Robinson; of Dr. Jakob's conscientious watchfulness over the quality and consistency of the agreements; of a charming dinner in the Ingenieure Haus which substituted casual conversation for the usual after-dinner speeches; of another dinner on the terrace of the Marble Hall; of learning the tricks of steam research over breakfast and luncheon tables; and of a jovial company on the train from Berlin to Copenhagen.

Aeronautics at Chicago

THE AIR meet at Chicago was in a way highly representative of the state of the air industry. On the one hand engineers were discussing such subjects as plywood in the aircraft industry, construction and operation of gliders, and future trends in aircraft design, while on the other, before vast crowds and under a cloudless sky, planes were performing hair-raising stunts and rushing through the air at speeds which only a few years ago would have been considered quite unbelievable. Both activities are legitimate and necessary. The aircraft industry needs further engineering progress in order to succeed—needs it, perhaps, beyond anything else. At the same time it also needs, urgently and vitally, popular support, and this support can be obtained only by showing the public what has already been achieved, and perhaps appealing to the love for the spectacular to which the American public is so responsive.

It is not uncommon for fatalities to accompany stunt flying, and the Chicago meet was no exception to this. No matter how greatly this is to be regretted, the paths blazed by pioneers, be they through the wilderness or through unknown regions in science and engineering, have always been marked by the bones of those who have perished in showing new ways for the world to travel. When machinery and human nerves are stressed to the utmost, it is not unusual to overstep the bounds a little. This happened in Chicago and, sad as it is, it will probably happen many times again on similar occasions when planes or automobiles or motor boats are driven at speeds or under stresses beyond anything that admits of reliable preliminary calculation.

The American Society of Mechanical Engineers took a prominent part in the engineering features of the Chicago meet.

James R. Fitzpatrick, in discussing plywood, pointed out that this material is no stronger than the glue which binds its veneers, and that it was not until the introduction of water-resistant glue that plywood could be considered an engineering material.

The subject of the construction and operation of gliders was discussed by Gilbert G. Budwig. The speaker advocated the revision of the Airworthiness Requirements of the Department of Commerce, and emphasized the necessity of intelligent glider operation, as there is a definite need for improvement throughout the country in the methods used. There is a somewhat general disregard for fundamental safety requirements. This was followed by constructive suggestions intended to assure greater safety and more satisfactory operation of gliders.

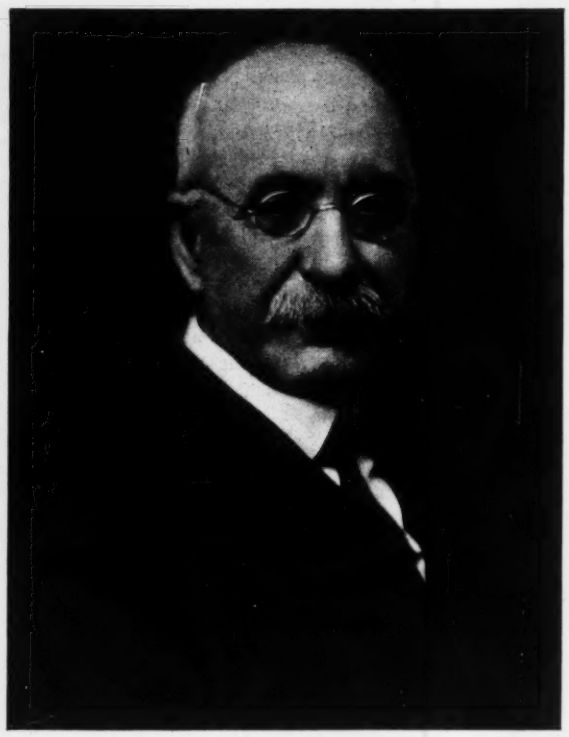
Wesley L. Smith spoke on the ice problem in aircraft, telling of the work of the National Air Transport undertaken to eliminate this important hazard. He spoke in particular of the work of Doctors Geer and Scott, who investigated the process of the formation of ice and discovered that it was possible to elimina te its power of adhesion to the plane by coating the latter with a certain oil, and told of the method that was finally adopted to eliminate the formation of ice on the planes.

The ever-present question as to the future trends in aircraft design was brought up for discussion by Robert R. Osborn. It would appear from what the speaker said that there are still many passenger-carrying planes that land at speeds in excess of 60 m.p.h., which means that they are capable of landing safely only on first-class fields. The Department of Commerce regulations prohibit the use of new planes of this type for the carrying of passengers, but the rules were not made retroactive in order to obviate the scrapping of much valuable equipment already existing. It is somewhat surprising that such apparently incontrovertible rules as "If the ship is aerodynamically unsafe the operator must realize that some time even his most skilful pilot can get into serious trouble with the airplane" still need proving, but apparently they do.

Ira Nelson Hollis

Naval Engineer, Educator, and Past-President, A.S.M.E.

IRA NELSON HOLLIS has lived that others might live better." These words, first printed nine years ago in their class book by seniors at Worcester Polytechnic Institute, of which he was then the president, aptly epitomize the character of the distinguished engineer and educator who died at his home in Cambridge, Mass., on August 15. His career, begun with nineteen years of service in the United States Navy, and continued through twenty years as professor of engineering at Harvard University, reached its culmination in the presidency of the Worcester Polytechnic Institute, which he held from 1913 to 1925. During a portion of this period he was also president of The American Society of Mechanical Engineers. On resigning the presidency of the Worcester engineering college because of failing health, he was elected by special action of the trustees to the honorary office of president emeritus. He returned to Cambridge, where he established a home at 985 Memorial Drive. His closing years were happily occupied with occasional travel, lecturing, and writing, and in the serene enjoyment of his books, his friendships, and rich memories. He is survived by four children, Janette R., Oliver Nelson, Elinor V., and Carolyn. His wife, who was Miss Caroline Lorman, of Detroit, died several years ago.



IRA N. HOLLIS

Dr. Hollis was the recipient of many academic honors, among them being the degrees of A.M. from Harvard University, L.H.D. from Union College, Sc.D., from the University of Pittsburgh, and D. Eng. from the Worcester Polytechnic Institute. He was a fellow of the American Society of Arts and Sciences, and a member of numerous scientific and engineering societies.

As president of The American Society of Mechanical Engineers, Dr. Hollis, at enormous expenditure of time and energy, visited in person nearly every local section of the Society, exemplifying thereby an ideal of service that has been a lofty challenge to his successors in that office. At the meetings of the Society he was always the central figure, constantly surrounded by hosts of fellow-members, who were drawn to him less by his official position than by his strong and appealing personality. For some years, both before and after his term of office, he served on the Council, and for a time was chairman of the important Committee of Awards, which position he resigned at the last annual meeting.

He was born at Mooresville, Indiana, on March 7, 1856. His parents were in such straitened circumstances that the boy was often sent to gather driftwood along the bank of the Ohio river to keep the home fires burning. He received his early education in the public schools of Louisville, Ky., and at an early age went to work in the railroad offices there. At this time he chanced to hear of an examination which was shortly to be given at Annapolis for admission to the Naval Academy, and determined to try for acceptance. As his preparation in some of the required subjects had been insufficient, he borrowed a number of books on mathematics, and resolutely set himself to master them. He had no money to defray the expenses of the journey East, but as an employee of the railroad was able to secure a pass. He took the examinations, received the highest rank of any of the 125 candidates, and was admitted to the Academy along with twenty-four others. He maintained first place throughout his course, and was graduated at the head of his class.

Assigned to the Engineering Corps, he was commissioned an assistant engineer in 1880, and a passed assistant engineer in 1888. One of his memorable experiences at sea was the chase of the filibuster *Itata* by the U.S.S. *Charleston*, the flagship of the Pacific Squadron, on which he was then the chief engineer. For his service on this occasion he was officially commended to the Navy Department by Admiral McCann. During his naval career he was detailed for a time as professor of marine engineering at Union College. Following his work at the college he became a member of the Advisory Board which built the White Squadron. During the summer of 1892 he delivered at the Naval War College a course of lectures on "The Ships of Our Modern Navy," and these lectures were afterward issued to the service in book form.

Twenty Years at Harvard

His brilliant reputation as an engineer in the Navy was recognized by Harvard University in 1893, when he was offered the position of professor of engineering in that institution. He thereupon resigned from the Navy, and devoted the rest of his life chiefly to the cause of engineering education.

At Harvard he at once manifested unusual abilities as a teacher. He remodeled and greatly developed the department of engineering, and became an outstanding figure in the Harvard faculty. He was chairman of the athletic committee for seven years, and it was under him that the Harvard Stadium was erected. His services were not entirely lost to the Navy, however, as in 1898 he was associated with Rear Admiral Wainwright in the reorganization of the personnel of the Navy, and the bill written by them was used as a basis for action in Congress. He also served twice on the board of visitors at the Naval Academy.

In 1913, after twenty years of teaching at Harvard, Professor Hollis was called to the presidency of the Worcester Polytechnic Institute. It was characteristic of the modest and retiring disposition of the man that he refused to sanction any public and formal exercises of inauguration, but, on July 1 of that year, quietly took up the duties of his office.

Soon after he arrived at the Institute he was called to face one of the severest crises that have confronted the college. The withdrawal of financial aid from the state left many of the colleges of the commonwealth, the Worcester Polytechnic Institute among them, in serious straits. President Hollis met the situation with courage, wisdom, and rare skill, and successfully piloted the Institute through the perils of inadequate finance to a sound and secure position among the engineering colleges of the country. A little later the Institute, along with other colleges, was plunged into new and distressing, if less critical, difficulties on the entrance of the United States into the World War. Only those who were then responsible for the safe conduct of the institutions of higher learning through a period when the students became soldiers, and responsibility was shared in strange and curious ways between the military officers and the officers of instruction, can adequately realize the delicacies and difficulties of the situation. Again Dr. Hollis was equal to the emergency. Through diplomacy and tact he succeeded in affording complete cooperation with the Government, while still insisting on maintaining sound scholastic standards. At the same time new financial problems were encountered in the necessity of advancing salaries to keep pace with the growing cost of living; and in the solving of these problems President Hollis was also eminently successful.

During his administration the Institute celebrated its fiftieth anniversary with elaborate ceremonies, participated in by representatives of the leading educational institutions of the country. On this occasion the corner stone of the alumni gymnasium was laid, thus opening a new era of athletic progress at the Institute, in the advancement of which President Hollis played a conspicuous part. It was under him, too, that the Tech Council was established, and won for itself an important rôle in the government of student life and activities.

Influence at Worcester Polytechnic Institute

But great as were the achievements that have been enumerated, one even greater remains to be mentioned. "It was not long after his arrival," wrote the seniors of 1916 in their class book, "before we learned that the Office . . . .was to be a place where our difficulties could be cleared up. We had only to state the extent of these, and 'Prexy' could immediately find a way out of them. Through his energy a change was made in the attitude of the upper classmen toward the freshmen. Class rushes were abolished; freshman rules were toned down; and many other changes made to increase the kindly feeling between classes. In his heart he had the welfare of every student; a kindly word of encouragement to the disheartened, or a well-meant reproof to the backward student, was all that was needed to point out the way he should go." The marked simplicity of his manner, the kindly sympathy of his speech, and his evident sincerity commanded the confidence and loyalty of the students, while their admiring respect was captured and held by his lofty attainments. The example he afforded them of real greatness combined with modesty of bearing and zealous will to serve, have left an ineffaceable impression upon the characters of them all.

Upon these engineering students, immersed in the pursuit of science, and often boasting their materialistic tendencies, President Hollis gained his commanding influence by the steadfast manifestation of a lofty idealism. His closing words in delivering the commencement address on the year of his coming to the Institute are an eloquent expression of the deeper philosophy of his life. "It seems to me," he said, "that we are on the entrance to a great moral and religious growth. Man is completely freed from his material environment by steam and water power, and he will grow rapidly into that faith and love which will solve most of our problems, if only he does not turn back. Let us not be led away by that common objection raised among self-styled practical people against all ideals, 'Oh, that would be the millenium.' Is the millenium the false fire that hovers over marshy ground, and that precedes us and vanishes as we are engulfed? Is it not rather the hope and goal of mankind, made possible and even probable by the proper use of man's time? I must believe that in this new freedom our descendants will gain a spiritual faculty over and beyond reason, that will teach them to follow and to understand instinctively the law of Christ given to us as the result of his ripe experience of life. When the lawyer asked him, 'Master, which is the great commandment in the law?' He replied, 'Thou shalt love the Lord, thy God, with all thy heart and with all thy soul and with all thy mind; this is the first and great commandment; and the second is like unto it: 'Thou shalt love thy neighbor as thyself. On these two commandments hang all the law and the prophets.' If the race comes to the practice of these two commandments as law, it will deserve the earth, and national, social, and industrial problems will dissolve in man's highest happiness. They are, in reality and truth, all the law and the prophets. Follow them as men, and you cannot fail to inherit the earth."

It was in the spirit of this philosophy that President Hollis devoted his life to the service of his students and his fellow-men. But his service was never limited to the individual: it was always freely extended to the collected individuals that make up the State. In his speech accepting the presidency of The American Society of Mechanical Engineers he urged his hearers to regard their work as an obligatory service of the state. "That," he said, "is our motto, and that is what we must strive toward during the coming year and all time as we must pass on into the higher atmosphere of goodwill, service, and cooperation."

CHARLES J. ADAMS.[1]

The Strength of Welded Bull Plugs

(*Continued from page 914*)

centrations developed in any one section. Five of the six bonnet heads burst at a section in the seam near the top of the head where the stress was greater than near the bottom of the head. All the ruptures in both types occurred in or at the edge of the seams. Had a higher test welding rod been used it is possible that some of the ruptures would have occurred in or extended into the head pipe metal, and this undoubtedly would have resulted in higher yield point and rupture stresses.

Results

In general, the results of the tests show that under similar conditions an orange-peel head may be expected to be twice as strong as a bonnet head of the same material, diameter, and wall thickness. With a medium rod and careful welding, a hemispherical orange-peel head should sustain a circumferential stress of 55,000 lb. per sq. in. while a bonnet head should sustain a corresponding stress of 28,000 lb. per sq. in. With these stress values a factor of safety of at least 2 should be used to forestall possible variations in head shape, material, and welding.

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[1] Professor of English, Worcester Polytechnic Institute, Worcester, Mass.; prepared in cooperation with Ralph Earle, president, and Charles M. Allen, professor of hydraulic engineering of the Institute.

Book Reviews and Library Notes

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The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Engineering Education

REPORT OF THE INVESTIGATION OF ENGINEERING EDUCATION, 1923–1929. ACCOMPANIED BY A SUPPLEMENTAL REPORT ON TECHNICAL INSTITUTES, 1928–1929. Vol. I. The Society for the Promotion of Engineering Education, Pittsburgh, Pa., 1930. Cloth, 6 × 9 in., 1039 pp., diagrams.

REVIEWED BY R. L. SACKETT[1]

THIS monumental volume contains the vast amount of data collected by the Society for the Promotion of Engineering Education in the course of its investigation of engineering education in the United States and Canada.

Prof. D. C. Jackson, when president of the S.P.E.E. in 1907, initiated a movement which resulted in a report by Dr. C. R. Mann, issued as a report of the Carnegie Foundation for the Advancement of Teaching. Plans for the later investigation first took definite form in 1922 in the address of the President, Charles F. Scott, who recently received the Lamme medal "for accomplishment in technical teaching or actual advancement of the art of technical training." The Carnegie Corporation contributed generously to financing the study, as did several industries and individuals.

The report of Dr. W. E. Wickenden, the director of the Investigation—now president of Case School of Applied Science—and the efficient associate director, Prof. H. P. Hammond of Brooklyn Polytechnic Institute, may be divided into three parts as follows: (1) The facts concerning students, graduates, and teachers; (2) The curriculum, including opinions of engineers, the influence of engineering societies, the cooperative plan; and (3) Technical education in Great Britain, Germany, France, and other countries.

STUDENTS

The data collected by the six special committees of the S.P.E.E. aided by a committee in each of the 138 institutions participating in the survey included a very thorough study of admissions and the rather stereotyped methods of selecting students. Selection and guidance are still unsatisfactory. The elimination of students for poor scholarship needs more study and better corrective measures. How can more accurate information be transmitted to high-school students, giving them the real picture of engineering practice and the necessary aptitudes? The American Society of Mechanical Engineers and other national societies should be factors through local sections and members. Engineers who are interesting speakers might serve the profession by addressing high-school assemblies.

[1] Dean of Engineering, Pennsylvania State College, State College, Pa. Mem. A.S.M.E.

Only a small percentage of graduates leave engineering. Their earnings, while low, show a progressive increase up to 25 years of useful experience or more.

THE TEACHER

The teacher receives a well-deserved study. Industry takes a considerable number of the most aggressive young teachers because college salaries are low. The time spent in preparation is considerable; advanced degrees are desirable; society dues, the cost of journals, books, and travel are items. Numerous demands are made on the teacher's time without compensation. Increased emphasis on research, on writing, and on graduate courses has taken from the time which might be devoted to consulting work.

Engineers and engineering executives will appreciate how inadequate the salaries of teachers are from Table 1 which is found on page 309 of the report.

TABLE 1 SUMMARY OF SALARY SCALES IN 69 REPRESENTATIVE INSTITUTIONS

Rank	No. of each rank	Maximum	Minimum	Median	Most frequent
Dean	54	$10,000	$2,500	$5,000	$5,000
Professor	700	7,500	2,500	4,000	4,000
Associate Professor	350	6,000	2,000	3,300	3,500
Assistant Professor	539	5,000	1,500	2,700	2,500
Instructor	831	3,000	900	2,000	2,000
Assistant	137	2,400	250	800	800
"Associate"	20	4,500	2,200	2,500	2,500
Total	2,631				

Engineering teachers supplement their salaries by incomes from professional work as shown in Table 2 from page 286 of the report.

TABLE 2 COMPARISON OF INCOMES OF TEACHERS IN INDUSTRIAL AND NON-INDUSTRIAL CENTERS

	Years after graduation	Number of individuals	Number reporting supplementary incomes	Per cent reporting supplementary incomes	Median total income	Median supplementary income
Industrial	1–10	508	361	71.1	$2530	$ 634
Non-Industrial	1–10	443	281	63.5	2105	408
Industrial	11–20	392	354	90.5	4270	995
Non-Industrial	11–20	340	286	84.2	3780	624
Industrial	21–30	218	194	89.0	5440	1460
Non-Industrial	21–30	163	138	84.7	4620	1052
Industrial	31–40	102	95	93.0	6740	2080
Non-Industrial	31–40	60	50	83.3	4610	1180

THE COST OF ENGINEERING EDUCATION

"The average student pays $172 per year in fees. This is 28.2 per cent of the average total cost per student, including interest." The nominal cost per graduate in 42 institutions, with 22,000 students, is $4251, with interest included. The total *investment* per graduate is estimated at $7720, weighted average, including land, buildings, and equipment utilized for the purpose.

CURRICULA

Both teachers and engineers agree that undergraduate instruction should be only "moderately" or "slightly" differentiated, the engineers leaning toward the lower degree of specialization.

Subjects and fields of study receive very thorough analysis. Economics should receive and is receiving more attention. Management, cultural subjects, and emphasis on the broader aspects of engineering subjects are given weight. Foreign languages and shop courses are critically considered; both have been receiving less attention than formerly. In the main, engineering curricula are sound, with sufficient variety to avoid stereotyped standardization.

The graduation requirements in mechanical engineering as reported by 83 institutions illustrate the diversity. The number of semester or credit hours required for graduation varies from 108 to 182.5, with 148 as the median. The number of credits required in strictly mechanical-engineering subjects varies from 22 to 72, and the number of credits required in other engineering subjects is somewhere between 17 and 50. The non-engineering subjects total between 40 and 80 credits. There are few free electives, though a choice of one subject from several is frequently provided. The median requirements in credits for a few subjects are as follows: Mathematics 17, English 10, Physical Science 20, Social Science 6, Foreign Language 0. The trend during the last 50 years has been toward more mechanical-engineering subjects as the art and science have developed, and toward less shop practice since about 1885. A marked reduction in foreign-language requirements with slight reduction in required mathematics has made room for more economics and an increase in other engineering subjects.

The cooperative form of work-study curricula is covered in Bulletin 12, and on pages 559 to 625 of this volume. The subject is thoroughly covered with a list of the institutions participating which includes 4 municipal, 2 Y.M.C.A., 4 sectarian, 3 endowed, and 2 state or state-supported institutions. The study of the various lengths of time spent in work and in study and the variety of curricula is thorough and interesting.

ATTITUDE OF THE PROFESSION TOWARD EDUCATION

"The engineering profession has never formulated a policy concerning the recruitment and training of its future members." "Forty years ago less than a quarter of the members of national engineering societies were college graduates; today more than two-thirds of those entering their membership hold college degrees and more than four-fifths have had a substantial amount of college training. The profession at large has accepted these changes passively."

The profession in general accepts the four-year curriculum as a norm, with shorter and more intensive vocational training for some; postgraduate study is the proper place for specialization.

"Engineering is concerned with technological, economic, and administrative problems; it has an immensely ramified scheme of individual specialization along both technical and functional lines and is further subdivided by grades of responsibility." "Engineers as a body hold to a highly realistic educational philosophy. In their judgment formal teaching should be limited largely to the underlying principles of engineering, its methods of analysis, its verbal, graphic, and symbolic language processes, and its setting in contemporary civilization." This chapter is a challenge to the engineering societies, and should be a powerful influence in engineering education.

ENGINEERING EDUCATION HERE AND IN EUROPE

"A Comparative Study of Engineering Education in the United States and in Europe" is an exhaustive analysis of the outstanding characteristics of technical training in Great Britain, France, Germany, and other countries and shows how diversified and well coordinated are the schools of various grades. We have much to learn in planning a more comprehensive and coherent system of technical and sub-technical education for the United States. This chapter (pp. 750 to 1015) is well worth careful study by teachers and by the societies concerned with engineering. It is undoubtedly the most exhaustive and searching analysis yet made. President Wickenden did an outstanding service to the profession by his keen and incisive study and by his excellent portrayal of European and American purposes and methods.

This volume and the survey which it presents constitutes a monumental contribution to the facts and the advancement of engineering education. It is not too much to say that it will influence technical training the world over for the next half century.

Robots or Men?

ROBOTS OR MEN? By H. Dubreuil. Harper & Brothers, 1930. Cloth, $5\frac{1}{2} \times 8\frac{3}{4}$ in., 248 pp., $3.

REVIEWED BY LILLIAN M. GILBRETH[1]

IT IS UNUSUAL to find a book that one looks forward to reading, reads, and looks back on reading with equal degrees of pleasure.

The author, as Dr. Person explains admirably in the preface, is a Frenchman who is well read and has worked long and understandingly in French industry. He comes to America to study industry here with the same thoroughness with which he has studied it in France.

His aim is to describe and interpret what we do, to his own countrymen, and he follows out his plan to get information at first hand by working in our plants. He limits himself to such work as he has had experience in or can easily adapt his training to—he is a skilled machinist—and to industry this side of the Mississippi. His work is practically all done in large and well-known plants.

As a result of careful planning and adequate preparation, the author gets what he came for, and succeeds in presenting his material in such a way that it cannot fail to be serviceable to the group for whom he got it.

But this gives no adequate idea of the book and its usefulness to us here in the United States of America. The writer is not only a keen observer, he is kindly, understanding, balanced, and has a sense of humor. He has an appreciation of likenesses and differences and the reasons for them that is rare. His alert mind, open eyes and ears, new slant, fairness, and optimism cannot fail to impress even a casual reader of his book.

Naturally the more intimately the reader knows American industry the more the comments of this shrewd observer mean to him. His criticisms of our employment procedure, with its unnecessary delays to the applicant; his comments on the speed at which we work, or fail to work, on the unevenness of our equipment, and on the absurdity of our refusing to use the metric system, may help us to find some things to correct in our procedure. His praise of our democracy, our willingness to "let's see what you can do," our elimination of heavy lifting and drudgery, make us wonder if we deserve all that is said.

It would be easy to quote at length to illustrate the fine philosophy that underlies the whole presentation. "Never had I appreciated so fully the savor of the liberty that comes from knowing how to work; never had I felt with so much pride the strength of the worker, and the genuine independence of the laborer wher-

[1] President, Gilbreth, Inc., Montclair, N. J. Mem. A.S.M.E.

ever 'Black hands produce white bread.'" "In looking at America, we ought to be just, but clear-sighted." "Thus I saw (in watching some delicate filing), with emotion, that in spite of the instruments invented by modern mechanical ingenuity, the human hand still has the last word, belying all the somber predictions recklessly made on the disappearance of the traditional trades and the gradual transformation of the entire working class into 'automatons.'" "My principal criticism of the systems is that they are still, in spite of efforts for greater fairness, based on some form of constraint external to the worker himself. The real solution—I could not repeat it too often—is to seek means of liberating the inner forces."

Interesting as the book is to a general reader—more so to a person trained in our industry—it speaks a special message to one working in the field of scientific management. It answers the question "Robots or Men?" with the word "men," but it contains explicit though tactful warnings that we must expand and adapt the findings of the pioneers to meet the needs of the human element today and tomorrow.

The book is not only profitable but easy and pleasant reading. The translation is smooth and convincing. Every device of effective arrangement is used. The translators have succeeded in effacing themselves and letting their author speak directly to the reader. If he is not invariably correct in his observations or his deductions, they have been wise enough to let him remain consistent and individual, so that we have a unified picture of present-day practice which brings to us suggestions for improvements. Some of these the author makes, others his stimulating and sympathetic presentation helps us to make for ourselves.

Simplified Aerodynamics

SIMPLIFIED AERO-DYNAMICS. By Alexander Klemin. Goodheart-Willcox Co., Inc., Chicago, Ill., 1930. Fabrikoid, 5 × 7 3/4 in., 323 pp., 212 figs., $3.50.

REVIEWED BY ARCHIBALD BLACK[1]

THIS book by Professor Klemin, of the Guggenheim School of Aeronautics, New York University, fully justifies its title. So many aerodynamicists have an inborn love for Greek letters and elaborate formulas that the student can scarcely be blamed if he loses interest in his subject. Hence, a work that avoids the use of higher mathematics should fill a useful purpose. The author of this work has previously shown his ability in imparting his knowledge to others and has lived up to expectations in "Simplified Aero-Dynamics." This work covers its subject very completely; in fact, considerably more so than might be suggested by the title. The drafting on some of the illustrations does not come up to the standard set by the text, but this defect is largely one of appearance, for the illustrations serve their purpose well otherwise. The aviation mechanic, the fledgling pilot, school boy, draftsman, or the man outside of the industry will find this book of great value. Indeed, even the experienced aeronautical engineer may find it helpful in cases where his memory has become somewhat rusty. On the whole, it is a very good book.

Books Received in the Library

THE AERONAUTICS BRANCH, DEPARTMENT OF COMMERCE. By Laurence F. Schmeckebier. Institute for Government Research of The Brookings Institution, Washington, D. C., 1930. Cloth, 5 1/2 × 8 1/2, 147 pp., $1.50.

This monograph on the history, activities, and organization of the aeronautics branch of the U. S. Department of Commerce is one of a series of studies of the services of the United States Government which are being prepared by the Institute. They are intended to serve the double purpose of furnishing an essential tool for efficient legislation, administration, and popular control, and of laying the basis for critical and constructive work on the part of those upon whom responsibility for such work primarily rests.

The present volume gives a brief outline of the development of aviation, an account of the movement for regulation, data on the growth of the aircraft industry, a detailed description of the work undertaken by the Aeronautics Branch, an account of the organization developed for the work, the text of the laws, and a description of the publications.

MY AUTOMOBILE; Its Operation, Care and Repair. By Harold F. Blanchard. Second edition. Scientific Book Corporation, New York, 1930. Fabricoid, 6 × 9 in., 373 pp., illus., diagrams, $3.50.

A clearly written manual, intended especially for those who wish to make minor repairs and adjustments. The directions for diagnosing troubles and for remedying them are specific and detailed. The book tells all that the average motorist needs to know about his car.

CONDENSERS FOR STEAM POWER GENERATING PLANTS. By V. A. Makeyeff. State Publishing Commission, Moscow, 1930. Paper, 6 × 9 in., 283 pp., 140 figs.

Carefully written text for the use of technical schools and engineering colleges. It gives the theory of various condensers and descriptions of some of the appliances thereto. Bibliography.

CONTRIBUTIONS TO THE HISTORY OF SCIENCE. By Louis Charles Karpinski and John Garrett Winter. University of Michigan, Ann Arbor, 1930. (University of Michigan Studies. Humanistic series, vol. 11.) Cloth, 8 × 11 in., 283 pp., portraits, facsimiles, $3.50.

Contains two monographs of value to historians of science. The first, by Professor Karpinski, upon Robert of Chester's Latin translation of the Algebra of Al-Khowarizmi, contains the Latin text and an English translation with notes, with a valuable essay upon the great Arab mathematician and his translator and their influences upon the development of mathematics. The second monograph, by Dr. Winter, contains an English translation of Steno's Prodromus, with a life of this great geologist. The book is a valuable addition to our information on early science.

COST FINDING FOR ENGINEERS. By Charles Reitell and Clarence Van Sickle. McGraw-Hill Book Co., New York, 1930. Cloth, 6 × 9 in., 518 pp., forms, $5.

A textbook intended to give students of engineering a working knowledge of cost finding. The basic principles of general accounting technique, the fundamentals of asset valuations, the use of control accounts, and the processes of unit product cost finding are set forth, giving the necessary background for higher cost-finding procedure. Those phases of general accounting which are only indirectly related to the problems of engineering are omitted.

ELEKTROTHERMIE; Die Elektrische Erzeugung und Technische Verwendung Hoher Temperaturen. Edited by M. Pirani. Julius Springer, Berlin, 1930. Bound, 6 × 9 in., 293 pp., illus., diagrams, tables. 36 r.m.

Lectures by specialists on the electrothermy of iron; electric melting furnaces for non-ferrous metals; the manufacture of silicon carbide, carborundum and alumina cement; artificial graphite; calcium carbide factories; fused quartz; the electrothermy of gases; electrothermal research work; and measuring instruments and processes. These were delivered in 1928 at an institute organized by the Vienna Technical High School.

[1] President, Black & Bigelow, Inc., New York, N. Y. Mem. A.S.M.E.

Synopses of A.S.M.E. Transactions Papers

THE papers abstracted on this and the following page appear in the current issues of Applied Mechanics, Hydraulics, Iron and Steel, Materials Handling, and Oil and Gas Power sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced when completed, in later issues "Mechanical Engineering."

APPLIED MECHANICS PAPERS

NATURAL FREQUENCY OF GEARS. By R. E. Peterson. [Paper No. APM-52-1]

The natural frequency of machine parts as related to the noise problem in machine operation is discussed in a general manner. Vibration phenomena in disks and rings are described in detail, following which the author discusses the manner in which a gear vibrates at its natural frequency. An empirical formula is given for the natural frequency of a gear in terms of its dimensions and material.

FACTOR OF SAFETY AND WORKING STRESS. By C. Richard Soderberg. [Paper No. APM-52-2]

This paper contains a general discussion of the fundamentals on which working stresses in machine parts should be based. The terms "failure" and "factor of safety" are also discussed. Rules for the determination of working stress as established by the East Pittsburgh Works of the Westinghouse Co. are given. It is stated as the author's opinion that the engineering profession is in need of a general code on the subject of working stress. The beginning of such a code has been made in the "Code for Design of Transmission Shafting" approved by the American Standards Association in 1927. In an appendix, this code is also discussed. It is hoped that this paper may lead to some action on the part of the A.S.M.E. toward the establishment of a general standard or code on the subject.

STRESSES AND DEFLECTIONS IN FLAT CIRCULAR PLATES WITH CENTRAL HOLES. By A. M. Wahl and G. Lobo, Jr. [Paper No. APM-52-3]

Simplified formulas are derived for calculating maximum stress and maximum deflection of flat circular plates having central holes. Eight different loading and edge conditions are considered. These formulas are presented in a usable form for the practical designer. Approximate solutions are given for purposes of checking the formulas. Using the principle of superposition, a simple method of superimposing fundamental cases is developed for calculating cases other than those considered in the paper. Experimental determinations of stress and deflection for certain cases indicate that the formulas are sufficiently accurate for practical work where the edge conditions are determinate. For indeterminate edge conditions, as, for example, so-called built-in edges, the tests indicate that while there is good agreement in the case of stress, the measured deflection is considerably greater than the theoretical.

HYDRAULIC PAPERS

INCREASED KILOWATT OUTPUT OF ADJUSTABLE-BLADE PROPELLER TURBINES. By C. R. Martin. [Paper No. HYD-52-1]

The commercial development of the adjustable-blade propeller-type hydraulic-turbine runner has been in a slow and careful manner, with the idea first of solving its mechanical difficulties and later of taking full advantage of the possibilities of high efficiency. The principal problem of the engineer in introducing a new design is to keep to a safe and reasonable program of development such as will not incur serious financial losses. In addition to the mechanical difficulties of the adjustable runner, there also have been many problems of regulation to be solved as well as the determination of a correct design of draft tube. This paper covers the gradual development and placing in service of the adjustable-blade runner in the United States to the time when the European design of automatic adjustable-blade runner was brought to this country.

The objectionable feature of the fixed-blade type of propeller runner is the peaked efficiency curve and the low efficiency at part-gate openings. By adjusting the runner blades one can operate at all the peak points of efficiency, reducing the disadvantage of part-gate operation. It is now possible to obtain a peak efficiency on a propeller-type runner that is within 1 to 2 per cent of the peak efficiency of Francis-turbine runners. The blades of a Francis runner are not adjustable, resulting in one-peak efficiency. The adjustable runner, therefore, with the possibility of adjusting its peak over a considerable range in load, makes it possible to obtain an average plant efficiency as high as that of the Francis runner.

CHANGING REQUIREMENTS IN HYDRAULIC TURBINE SPEED REGULATION. By Forrest Nagler. [Paper No. HYD-52-2]

Flyball control of units such as are now operated in the plants of large systems may be of secondary importance for normal conditions. It is a control for large or sudden changes, a shutdown device for emergency purposes, and it effects certain conveniences in operation. It is of real use only in emergency conditions, it is entirely ineffective when a unit is on the load limit, and it is entirely ineffective when the gate position is controlled by frequency under gradual load change conditions. It comes into play in case of line troubles or when load changes are faster than the frequency control can meet.

Practically complete governing equipment can be built without a large flyball, and with probable ultimate simplification of governing equipment. Emergency stop and emergency start would be obtained simply by making secondary contact at an abnormally high or low frequency point that would take the unit off the line or at least close it to "speed-no-load" condition.

It is not suggested that governors be eliminated. Many of their elements are very satisfactory. The oil-pressure systems now in use are probably the best form of speed-reducing mechanism for the purpose, reducing 600- to 1200-r.p.m. motor speed to as low as 1 r.p.m. It is suggested that they no longer be governors from a normal speed-control standpoint with its possible wide range of gate movement.

IRON AND STEEL PAPERS

PROGRESS IN THE IRON AND STEEL INDUSTRY IN 1929. Contributed by the Iron and Steel Division. Executive Committee: C. Snelling Robinson, *Chairman*, F. C. Biggert, Jr., W. Trinks and W. W. Macon. [Paper No. IS-52-1]

This gives the progress made by the iron and steel industry in 1929. Some of the subjects discussed include iron ore, coal, coke, blast furnaces, rolling mills, pipe, wrought iron, alloy steels, nitriding, centrifugal casting, and foreign patents.

USE OF ALLOY STEELS IN IRON- AND STEEL-MILL EQUIPMENT. By E. R. Johnson and O. Bamberger. [Paper No. IS-52-2]

Substituting alloy steels for the ordinary carbon steels in its mill equipment is the practice of the Central Alloy Steel Corporation when occasion arises to make a change. Elimination of breakdowns and costly repairs is claimed to be furthered by certain uses of the alloys. A gradual building up of the alloy-steel equipment is taking place. Producing alloy steel itself, the initial cost is low. There are three requirements which permit the substitution of alloy steels: (1) Increase of the physical properties of strength, ductility, and toughness. (2) The ability to withstand wear and abrasion. (3) Resistance to corrosion.

RECENT DEVELOPMENTS IN BLAST-FURNACE DESIGN AND CONSTRUCTION. By Arthur G. McKee and Wm. A. Haven. [Paper No. IS-52-3]

This paper deals with two recent and highly important developments in blast-furnace construction and practice: namely, the trend toward furnaces having daily capacities of 1000 tons or more, and

the profitable utilization of blast-furnace gas in the firing of coke ovens, making open-hearth steel, and in the various types of heating furnaces employed in steel mills. These developments have involved certain structural changes in the stacks, which have in time necessitated changes in such auxiliaries as stock-house and blowing equipment, gas cleaners, hot-blast stoves, and boilers. These are all considered in detail by the authors.

MATERIALS HANDLING PAPERS

PROGRESS IN MATERIALS HANDLING. [Paper No. MH-52-1]

This report, which is profusely illustrated with views of new handling devices, deals with progress during 1929 under the following heads: Clay products; railroads; the packing industry; industrial trucks; cranes and conveyors; and skid shipment.

FUNDAMENTALS WHICH SHOULD BE OBSERVED IN DESIGN AND APPLICATION OF TRAMRAIL SYSTEMS. By E. T. Bennington. [Paper No. MH-52-2]

The design of overhead conveyors and tramrail systems has gone through its period of expansion, change, and improvement with the results that this type of machinery is playing a very important part in a great many intensified and concentrated production schedules, and it is the expectation of those that are following the development of this business that it is destined to play a far more important part in the very near future.

There are many fundamental principles of design for overhead-conveying machinery that cannot be safely overlooked if a system is to be subjected to severe service. Even if it is not to be subjected to severe service, from the standpoint of safety and ease of handling, these principles should all be understood and observed. This paper contains only a few important principles of design and application.

INCENTIVE PAYMENT PLANS FOR MATERIAL HANDLING. By C. A. Fike. [Paper No. MH-52-3]

In this paper the author describes the methods used in installing incentive payment plans on two different phases of material-handling activities at the East Pittsburgh plant of the Westinghouse Electric & Manufacturing Company. The first phase is that of industrial electric trucking, the other is a material-supply group in the motor-manufacturing department. Detailed formulas are included.

THE APPLICATION OF AERIAL TRAMWAYS TO LONG AND SHORT HAULS. By M. P. Morrison. [Paper No. MH-52-4]

Aerial tramways are of value where no other means of transportation is possible and also in competition with other methods of transportation. The difficulties of an engineering nature are easily overcome. The advantages over other methods are independence of weather conditions, independence of ground conditions such as crossing streams, roads, ravines, and mountains, thus avoiding expensive tunneling or trestle work, and the easy protection of property by guard screens over railroads, highways, and buildings. With aerial tramways, the length and capacity are unlimited from an engineering standpoint. Tramways have been built up to 54 miles. An extremely long tramway can be built in several sections. There are tramways with a capacity up to 400 tons per hour in successful operation. Extreme length and capacity are sometimes limited from a commercial standpoint, where long railroad hauls are more economical. In the handling of material a small amount of labor is required. A tramway of 200 tons per hour can be operated by one man and a helper, with no rehandling of material. The aerial tramway is applicable for large construction jobs. There is a 220-tons-per-hour tramway for dam construction running 24 hours per day. Among tramways of special design are the tramway at Alabaster Mich., which carries 300 tons per hour of gypsum rock from a shore bin to a lake dock 6600 ft. out; a tramway at Gerlach, Nev., which carries 100 tons per hour of gypsum rock $5^1/_4$ miles to a discharge terminal with the special feature of discharging into a bin or of forming a big stock pile outside of the station.

OIL AND GAS POWER PAPERS

PROGRESS IN OIL- AND GAS-POWER ENGINEERING. Contributed by the Oil and Gas Power Division. Executive Committee: E. J. Kates, *Chairman*, L. H. Morrison, *Secretary*, H. A. Pratt, Harte Cooke, and L. M. Goldsmith. [Paper No. OGP-52-1]

This outlines progress made in aircraft oil engines, marine oil engines, new materials and processes, and oil-engine research.

SERVICE CHARACTERISTICS OF DIESEL-ENGINE LUBRICATING OIL. By A. E. Flowers and M. A. Dietrich. [Paper No. OGP-52-2]

Diesel-engine lubrication has presented difficulties owing to the high compression pressures and the high temperatures and to the great weight of engine parts. Results are given of a study of the progressive record of the characteristics of the lubricating oil used in a Diesel engine in regular service for about a year installed in a freight-switching locomotive running 23 hours of the day.

THE GAS ENGINE AND ITS APPLICATION IN OIL-FIELD ENGINEERING. By George L. Reid. [Paper No. OGP-52-3]

The paper presents specific information in regard to engineering problems and progress relative to the processes of oil lift. Drilling is accomplished by two methods in the United States. The older one is by the cable tool, standard, or percussion system, and the later one is by the rotary system. Engineering in respect to drilling is on a firm basis. The geologist has predetermined the structures. The tools and power requirements are known within a close factor of accuracy. In order to reduce the tremendous losses sustained through dry holes or wells which fail to pay for themselves, it was necessary that scientific methods be developed.

NOTE: Those who have not registered in the A.S.M.E. Applied Mechanics, Hydraulics, Iron and Steel, Materials Handling, and Oil and Gas Power Divisions whose papers are abstracted on this and the previous page, and who desire copies of any of these papers, may obtain them by using the form given below.

TO THE SECRETARY, A.S.M.E., 29 West 39th Street, New York, N. Y. Date.....

Please send copies of papers checked below:

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Iron and Steel [IS-52-1] [IS-52-2] [IS-52-2]

Materials Handling [MH-52-1] [MH-52-2] [MH-52-3]

Oil and Gas Power [OGP-52-1] [OGP-52-2] [OGP-52-3]

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Current Mechanical Engineering Literature

Selected References From The Engineering Index Service

(The Engineering Index Service Is Registered in the United States, Great Britain, and Canada by the A.S.M.E.)

THE ENGINEERING INDEX SERVICE furnishes to its subscribers a Weekly Card Index of references to the periodical literature of the world covering every phase of engineering activity, including Aeronautic, Chemical, Civil, Electrical, Management, Mechanical, Mining and Metallurgical, Naval and Marine, Railway, etc. Of the many items of particular interest to mechanical engineers a few are selected for presentation each month in this section of "Mechanical Engineering." In operating The Engineering Index Service, The American Society of Mechanical Engineers makes available the information contained in the more than 1800 technical publications received by the Engineering Societies Library (New York), thus bringing the great resources of that library to the entire engineering profession. At the end of the year all references issued by the Service are published in book form, this annual volume being known as The Engineering Index.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ABRASIVES MATERIALS

Manufacture. Metal Abrasives, A. B. McDaniel. Metals and Alloys, vol. 1, no. 13, July 1930, p. 614, 1 fig. Review of manufacture, uses and research on grit, shot and sand of iron and steel for abrasive and cleaning purpose data on shot and grit production in United States and on export and import are given.

AERIAL PHOTOGRAPHY

Cameras. New Photographic Equipment for Air Forces (Le nouveau materiel photographique des forces aériennes), Orselli. Revue des Forces Aériennes (Paris), no. 11, June 1930, pp. 696–708, 17 figs. Notes and data on automatic and semi-automatic cameras made by Duchatellier and Labrély-Richard; brief description of developing and drying machines for films.

AERIAL TRANSPORTATION

Accident Prevention. The Department of Commerce Position in Accident Publicity, W. P. MacCracken, Jr. Aero Digest, vol. 16, no. 4, Apr. 1930, pp. 53, 248 and 250. Brief description of difficulties found by Crash Board of Department of Commerce in analyzing causes of accidents.

Economics. The Economic Status of Airline Operation, H. M. Hanshue. Aero Digest, vol. 16, no. 5, May 1930, pp. 57, 258 and 260, 1 fig. Brief analysis of factors controlling airline operation; government cooperation, Kelly and Watres bills; data on rates are given.

Radio Communication. Two-Way Radio Communication in Air Transport Service, H. Hoover, Jr. Aero Digest, vol. 16, no. 4, Apr. 1930, pp. 62–63 and 278, 5 figs. Brief review of developments; wave bands and antennas are discussed regarding distance; radio telephone equipment now commercially available weighs about 150 lb., including power supply; power of 50 watts, if fully modulated appears to fulfil all requirements on plane; while 400 watts if fully modulated will cover requirements on ground.

AERONAUTICAL EDUCATION

Schools. Running a Flying School, H. H. Davis. Airways (Lond.), vol. 6, no. 11, Aug. 1930, pp. 419–420, 1 fig. Flying now pastime for those not seeking hair-raising thrills and narrow escapes from death, though adventure remains; flying schools for practical people who see aviation to be most convenient mode of travel in future; outline of courses.

AIR COMPRESSORS

Maintenance and Repair. Care and Maintenance of 8½-Inch C.C. Compressor, C. D. Nicholls. Railroad Herald, vol. 34, no. 6, May 1930, pp. 28–32. Practical discussion of proper methods to be employed in maintenance and repair of locomotive air compressors. Presented before Southeastern Air Brake Club.

AIR CONDITIONING

Refrigeration. Cooling and Heating With One Unit, E. Guarini. Ice and Cold Storage (Lond.), vol. 33, no. 386, Mar. 1930, pp. 122–123, 2 figs. Use of electrically driven refrigerating machines in inhabitated premises for heating in winter and for cooling in summer; heating effected by use of electric aerotherms; cost of heating and cooling. Abstract of address before Belgian Soc. of Electricians.

AIRPLANE ENGINES

Design. Developments of Aircraft Engines From 1912 to 1930 (Gli sviluppi del motore di aviazione dal 1912 al 1930), G. Lauro. Atti del Sindacato Provinciale Fascista Ingegneri di Milano (Milan), vol. 8, no. 4, Apr. 1930, pp. 135–154, 31 figs. Comparative study of airplane engine of Italian design; critical discussion of mechanical, metallurgical, and thermodynamical aspects; table giving specifications and performance data for Isotta Fraschini engines; notes on possibilities of future developments.

The Development and Progress of the Aero Engine, H. R. Ricardo. Flight (Lond.), vol. 22, no. 23, June 6, 1930, pp. 616–620; see also Aeroplane (Lond.), vol. 38, no. 23, June 4, 1930, pp. 1075–1076, 1078 and 1080, 4 figs. Review of development and outline of possibilities of improved designs; data on fuel consumption and weight; air vs. water cooling; supercharging; notes on sleeve-valve performance; exhaust at pressure of 300 lb. per sq. in. can be used in low-pressure cylinder; data on compression ignition. Abstract of Wilbur Wright Memorial Lecture presented before Roy. Aeronautical Soc.

Diesel. Diesel Engine in Aviation (El Motor Diesel en la Aviacion), C. Ordonyez. Revista de Ingenieria Industrial (Madrid), vol. 1, no. 2, June 1930, pp. 11–19, 14 figs. Aviation pilot discusses development of Maybach, Bearsmore, Sunbeam, Packard, Junkers and Garuffa types; injection, lubrication, starting, and operation.

Scavenging and Supercharging Blower Developed for Diesel Aircraft Engine. Automotive Industries, vol. 63, no. 2, July 12, 1930, pp. 47–48, 3 figs. Description of pumps with capacity of 20 liters (0.7 cu. ft.) per revolution of driving shaft intended to operate at 2000 r.p.m.; blower with housing of Elektron weighs 44 lb.; experiments made with model indicate that volumetric efficiency of 90 per cent may be expected for air pressures not exceeding 15 lb. per sq. in.

Liquid-Cooled. Water-Cooled Aero Engines (Six-Years' Progress), A. J. Rowledge. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 34, no. 235, July 1930, pp. 578–590 and (discussion) 590–602, 9 figs. Discussion of design and development of water-cooled engines of various makes; data on Rolls-Royce engines; notes on variable-pitch propeller and supercharging; in units of more than 500 hp. liquid cooling seems to be superior to air cooling.

Manufacture. Machining Airplane Engine Cylinder Heads. Machy. (Lond.), vol. 36, no. 928, July 24, 1930, pp. 521–523, 4 figs. Spherical and straight boring, tapping and facing operations on cylinder heads performed on Mult-Au-Matic at new engine plant of Curtiss Aeroplane & Motor Co.; sketches show diagrammatic views of cuts taken at various stations of machine.

Machining Parts for Wright "Whirlwind" Engines, V. P. Winter. Modern Machine Shop, vol. 2, no. 12, May 1930, pp. 64, 69–70, and 72, 9 figs. Machining operations on crankshaft are explained.

Testing. All Major Parts Contribute to Failures in A.T.C. Aircraft Engine Tests. Automotive Industries, vol. 63, no. 4, July 26, 1930, pp. 118–121 and 132, 5 figs. Outline of type test procedure and requirements for approved type certificate of Department of Commerce; notes on equipment of aircraft engine-testing laboratory of Aeronautics Branch, Department of Commerce, at Arlington, Va.; principal causes for failures are discussed.

AIRPLANE PROPELLERS

Design. Joukowski's Vortex Theory of Propellers, M. Watter. Aero Digest, vol. 16, no. 4, Apr. 1930, pp. 78–80 and 234, 12 figs. Diagrams give data on power coefficients, propeller efficiency; ratio of observed to calculated values of coefficients at maximum propeller efficiency; thrust coefficients.

Light Reflection. Luminous Reflections of Rotating Propellers (Riflessione luminosa delle eliche in rotazione), V. S. Kulebakin. Notiziario Tecnico Di Aeronautica (Rome), vol. 6, no. 3, Mar. 1930, pp. 235–242, 12 figs. Experiments on light-reflecting properties of propellers for elimination of disturbing effects during night landings; dull dark color gives best results. Translated from Zeit. fuer Flugtechnik und Motorluftschiffarht.

AIRPLANES

Amphibian. The Saunders-Roe Cloud. Aeroplane (Lond.), vol. 39, no. 4, July 23, 1930, pp. 248 and 250, 2 figs. Description of Saro Cloud, 6 to 8-seat machine which can have any combination of power units that total about 600 hp., such as: two Lynx Major engines (total 520 hp.), two Lynx engines (total 450 hp.), three Lynx engines (total 645 hp.) or 3 mongoose engines (total 450 hp.); machine is high-wing cantilever carrying engines above wings mounted on inverted pyramidal mountings and based inboard by struts.

Design. Rigidity of Bolts in Wooden Parts (Festigkeit von Bolzen in Holzbauteilen) Maschinenbau (Berlin), vol. 9, no. 9, May 1, 1930, pp. 306–309, 10 figs. Description of tests for investigating pressure distribution between wooden blocks and bolts by subjecting assembly to tensile stresses; results and physical properties of materials are given in graphs.

Framework. Building the Framework of the Moth Plane, F. C. Duston. Machy. (N. Y.), vol. 36, no. 12, Aug. 1930, pp. 970–972, 4 figs. Outline of procedure of Moth Aircraft Corp., followed in building wooden framework for wings, fins, ailerons, and similar parts, and application of fabric covering to these elements; notes on doping and painting of fabric.

Fuselages. Constructing Fuselages for Airplanes. Machy. (Lond.), vol. 36, no. 922, June 12, 1930, pp. 321–325, 5 figs. Notes on properties and proportions of tubing used; autogenous-welding practice; construction of important details; saving in weight by using alloy steel; strength and toughness; fittings for fuselage.

Ice Formation. The Formation of Ice on Aircraft, V. O. Clapp. U. S. Naval Inst.—Proc., vol. 56, no. 330, Aug. 1930, pp. 743–744. Conditions under which ice formations occur; data obtained in sixty altitude flights.

Maintenance and Repair. Equipment for the Aircraft Service Station, E. W. Fair. Aviation, vol. 29, no. 1, July 5, 1930, pp. 20–22, 3 figs. Descriptions of tools and machines necessary for efficient and profitable operation of small or large service; table gives primary small tools used for general maintenance in aircraft service stations shop.

Maintenance at Roosevelt Field, N. Y. Airway Age, vol. 11, no. 7, July 1930, pp. 934–937, 11 figs. Outline of system of records and inspection used by Roosevelt Field Corp. of Minneola, L. I.; blank forms of airplane flight and others are given; data on overhaul periods and expenses.

Metal Construction. Metal Aircraft Production. Automobile Engr. (Lond.), vol. 20, no. 269, July 1930, pp. 245–248, 12 figs. Manufacturing operations and equipment at works of Boulton and Paul, Ltd.

Applications of Stampings, Forgings and Castings in Aircraft Construction, H. G. Runde. Am. Soc. Testing Matls.—Advance Paper, no. 33b, for mtg. June 23 to 27, 1930, 11 pp., 15 figs. In general, built-up or machined fitting is used for very small production; castings, with due regard for their lower physical properties, in designs of intricate shape and for production of intermediate quantity; stampings and forgings for mass production and where improved physical properties, increased soundless and greater reliability are required; illustrations of typical aircraft parts.

Pilots. See AVIATORS.

Radio Apparatus. Aircraft Radio Receivers and Broadcast Service, J. C. Hromada. Airway Age, vol. 11, no. 7, July 1930, pp. 922–925, 6 figs. Outline of requirements of aircraft receivers and description of equipment built by Western Electric, Radiomarine Corp. of America and other companies; notes on electric circuits, power supply, etc.

Testing. Aerodynamic Research Flying, S. Scott-Hall. Roy. Air Force Quarterly (Lond.), vol. 1, no. 2, Apr. 1930, pp. 281–290. Discussion of methods for determination of aerodynamic characteristics of airplane; notes on instruments for measuring air speeds, acceleration and current recorders.

Duration Flights During 1929, H. B. Hendrickson. Aero Digest, vol. 16, no. 4, Apr. 1930, pp. 64–65 and 272, 274, 276, and 278. Description of outstanding events in 1929 and equipment; graph of record refueling flights and graph of solo duration flights.

Welding. See WELDING.

AIRPORTS

Burbank, Calif. The United Airport at Burbank, Calif. Airway Age, vol. 11, no. 7, July 1930, pp. 945–951, 12 figs. Description of layout and construction of 243-acre airport; notes on runway, lighting, and building.

Croydon. London's Central Airport. Airways (Lond.), vol. 6, no. 11, Aug. 1930, pp. 391–392, 2 figs. Inconvenience of location; advantages of Berlin airport contrasted; advocation of ten-minute electric express to Croydon Aerodrome; possible locations nearer heart of city described.

Lighting. Careful Planning Pays in Airport Lighting, F. S. Peterson. Elec. World, vol. 96, no. 6, Aug. 9, 1930, pp. 259–260, 3 figs. Care used in preliminary study and planning; centralized remote control and underground distribution are features of Denver's airport lighting.

Runways. Two-Course Asphalt Surfacing for Airport Runways, N. H. Angell. Eng. News-Rec., vol. 105, no. 6, Aug. 7, 1930, pp. 215–217, 4 figs. Description of two-course asphaltic surfacing, designed to meet unusually rigid specifications for runways of United Airports, recently completed at Burbank, Calif.; surface hardness under temperature changes controlled by mixed-in place base course and premixed topping; grading of aggregate for plant-mixed course.

AIRSHIPS

Hull Stress. The Strength of Transverse Frames of Rigid Airships, H. M. Lyon. Roy. Aeronautical Soc.—Jl. (Lond.), no. 234, June 1930, pp. 497–556, 14 figs. Mathematical investigation of methods which may be used to estimate loads in members and deflections at joints of frame under system of external loads in plane of frame, and in case of space frame, of forces perpendicular to plane of symmetry of frame.

Mooring Masts. St. Hubert Awaits the R-100, D. MacInnes. Power Age, vol. 7, no. 6, June 1930, pp. 36–40, 4 figs. Description of mechanical and physical features of mooring tower at St. Hubert Airport, near Montreal, Que.

R-101. New British Dirigible R-101 (Le nouveau dirigeable anglais "R. 101"), G. Delanghe. Le Génie Civil (Paris), vol. 96, no. 26, June 1930, pp. 621–629, 17 figs. Brief review of airship development and types; description of design of 142,000 cu. m. dirigible; sketches show structural details.

ALLOYS

Aluminum. See ALUMINUM ALLOYS.

Bearing Metals. See BEARING METALS.

Cast Iron. See CAST IRON.

Refining. Refining of Eutectic Structures (Affinamento di strutture eutettiche), F. De Carli. La Metallurgia Italiana (Milan), vol. 22, no. 6, Apr. 1930, pp. 463–468, 8 figs. Review of methods of refining eutectic structures of aluminum-silicon alloys by adding small quantities of metals or of alkaline fluorides; report on other studies of effects of additions of sodium to such alloys as copper-antimony, copper-zinc, copper-cadmium, tin-antimony, tin-cadmium, bismuth-tin, etc.; theoretical explanations.

ALUMINUM ALLOYS

Bronze. Aluminum Bronze—A Corrosion Resistant Alloy, R. J. Anderson. Metallurgia (Lond.), vol. 2, no. 8, June 1930, pp. 57–60. Brief review of development of aluminum bronze, known prior to 1860, but formerly too costly for use as engineering material of construction; compositions and mechanical properties; resistance to corrosion by various media; applications under corrosive conditions. Bibliography.

Corrosion. Some Factors Contributing to Corrosion of Aluminum, M. I. Makushenko. Tzvetniye Metalli (Moscow), no. 3, Mar. 1930, pp. 348–365, 37 figs. Report on experimental study made at laboratory of Krassny Viborzhetz plant, in Leningrad, on corrosive effect of river water, acid solutions, cooked rice, etc., upon aluminum ware and samples of aluminum plate. (In Russian.)

Hiduminium. Hiduminium—A New Alloy Development. Metallurgia (Lond.), vol. 2, no. 8, June 1930, pp. 52–53, 2 figs. Notes on alloy developed at laboratory of Rolls-Royce Co., and for which patent has been issued; in place which won Schneider Trophy, crankcase, cylinder block, and cylinder head were produced from this alloy; in addition to aluminum it contains 0.5 to 5.0 per cent copper, 0.2 to 1.5 nickel, 0.1 to 5.0 magnesium, 0.6 to 1.5 iron, to 0.5 titanium, and 0.2 to 5.0 per cent silicon; test data are given.

Oxidation. Physical Technological Properties of Insulating Layer of Aluminum Oxide (Die physikalisch-technologischen Eigenschaften der Aluminiumoxydisolationsschicht), H. Schmitt and L. Lux. Hauszeitschrift der V.A.Q. u.d. Erftwerk A.G. fuer Aluminium (Berlin), vol. 2, no. 3, June 1930, pp. 75–81, 7 figs. Review of physical properties of oxidized aluminum wire; outline of technical properties for which it is particularly used. See also succeeding article, by H. Ginsberg, pp. 81–84, 1 fig., entitled, Basic Principles in Electrolytic Oxidation of Aluminum.

Testing. Flow Tests Under Constant Pressure on Aluminum and Alpax (Essais de coulabilité, sous pression constante, de l'aluminum et de l'alpax) A. Courty. Académie des Sciences—Comptes Rendus (Paris), vol. 190, no. 15, Apr. 14, 1930, pp. 936–938. Pressure of molten metal is kept constant by flap-valve arrangement in form of thin lead sheet; values obtained by this method check well; refinement with alkali, repeated fusions, duration of heating and overheating have only insignificant influence upon fluidity of alpax, in contrast to their influence upon its mechanical properties.

AUTOMOBILES

Radiators. Ford Rustless Steel Radiator Shells Need 17 Press Operations, J. Geschelin. Automotive Industries, vol. 63, no. 2, July 12, 1930, pp. 44–46 and 48, 3 figs. Outline of method and technique for deep drawing rustless-steel and automatic polishing and buffing; data on heat treatment of draw die and rings used in production of Ford radiator shells.

AUTOMOBILE TRANSMISSIONS

Design. Transmissions Designed to Multiply the Engine Torque Must Have Some Point of Reaction on the Chassis Frame, P. M. Heldt. Automotive Industries, vol. 63, no. 3, July 1930, pp. 90–91, 1 fig. It is impossible to float speed-change gear on line of shafting as engine structure takes reaction to engine torque only and additional torque due to speed demultiplication must be provided against elsewhere; several transmission designs are discussed with regard to this principle.

Free Wheel. The Millam Free Wheel and Sprag. Automobile Engr. (Lond.), vol. 20, no. 268, June 1930, pp. 228–229, 6 figs. Description and sketches of free-wheel and sprag mechanism; notes on advantages and performance; saving in gasoline, oil, tires, and engine wear.

AVIATION

Blind Flying. For Flying Equipment. Aircraft (Melbourne), vol. 8, no. 9, June 30, 1930, pp. 374, 376, 378, 380, 382, 384, and 386. On September 24, 1929, demonstrations under Guggenheim Fund's direction proved conclusively that aircraft can take-off and land by instruments alone; advantages of gyroscope; test plane equipped with Radio Frequency Laboratory standard aircraft receiver and vibrating reed indicator; aural type radio beacon, purposes of which was to direct incoming aeroplane to vicinity of field, visual type of localizer beacon to lead pilot to exact point on aerodrome and ground receiving and transmitting set.

AVIATORS

Training. Training Master Pilots, G. Myers. Airway Age, vol. 11, no. 6, June 1930, pp. 798–800. Outline of education methods of Boeing School of Aeronautics; notes on progress checks; instrument flying, types of planes, etc.

B

BEARING METALS

Developments. Bearing Metals and Bearings, W. M. Corse. Am. Soc. for Steel Treating—Trans., vol. 18, no. 2, Aug. 1930, pp. 179–203. Development of bearings and bearing metals; discussion of requirements of good bearing metal and description of properties of white metals, bronzes, and graphite bearing metals; utility of tests most commonly applied to bearing metals is discussed and summary given of important work on bearing bronzes at Bureau of Standards; brief non-mathematical résumé is given of theory of lubrication, both for thick and thin lubricant films; effects of various physical and chemical properties of lubricant are discussed.

BEARINGS

Roller. Testing of Tapered Roller Bearings (Die Pruefung von Kegelrollenlagern), G. Oehler. Werkstattstechnik (Berlin), vol. 24, no. 9, May 1, 1930, pp. 244–247, 20 figs. Description of new test methods for tapered roller bearings; actual measurements show conformity of various test methods; graphs give data on thickness, blackness, and hardness of outer races.

BELTS AND BELTING

Rubber. Stretch in Rubber Transmission Belting, C. W. Staacke. Am. Soc. Testing Matls.—Advance Paper, no. 103, for mtg. June 23–27, 1930, 13 pp., 7 figs. Investigations were made to determine proper amount of inelastic stretch to remove from belting during vulcanization process when using given fabric; eight identical samples of 6-in. 4-ply belting were given amounts of stretch varying from zero to 11.6 per cent; in case of this particular construction belt stretched between 7 and 8 per cent during vulcanization will render satisfactory service.

BLAST FURNACES

Practice. Interaction of Gases and Ore in the Blast Furnace. Fuels and Furnaces, vol. 8, no. 8, Aug. 1930, pp. 1089–1090. Discussion of carbon deposition of 450 deg. C. and its influence upon ore reduction; equilibria between gases and ore at 650 to 1000 deg. C. Paper presented before British Iron and Steel Institute.

BOILERS

Design. Increase in Efficiency of Boilers and Its Influence on Price of Steam (Die Leistungssteigerung von Kesseln und ihr Einfluss auf den Dampfpreis), H. Maas. Zeit. des Bayerischen Revisions-Vereins (Munich), vol. 34, nos. 11 and 12, June 15, 1930, pp. 153–154 and June 30, pp. 170–172, 3 figs. Conditions governing increase in efficiency; tests of performance with increasing steam output; economic considerations and ad-

vantages; based on practical examples investigation is made as to whether increase in capacity of boiler effects reduction in cost of steam generation.

Marine, High Pressure. Marine Steam Boiler. Engineer (Lond.), vol. 149, no. 3884, June 20, 1930, p. 696, 2 figs. Each boiler has total surface of 8880 sq. ft. designed for 500 lb. working pressure and superheat of about 280 deg. fahr., air being preheated before reaching burner openings; boilers were designed by J. I. Thornycroft and Co. in collaboration with Admiralty.

Operation. Operation of Internally Fired Boilers (Wichtiges aus dem Flammrohrkessel-Betriebe). Waerme (Berlin), vol. 53, no. 22, May 31, 1930, p. 402; see also brief translated abstract in Eng. and Boiler House Rev. (Lond.), vol. 44, no. 1, July 1930, p. 58. There is tendency in boilers of Lancashire type for ash to accumulate at bottom of flue; output can be increased by using circulating device to raise cold water from bottom of boiler, and to assist in removing steam bubbles from upper surface of flue; another means of improving efficiency is by use of special baffle beyond firebridge to impart spiral motion to flue gases.

Pulverized—Coal Fired. Notes on Examination of Boiler Fired With Pulverized Coal (Observacoes sobre a exploracao de uma caldeira a carvao pulverizado), I. Maria Simoes. Revista de Associacao dos Engenheiros Civis Portugueses (Lisbon), vol. 61, no. 659, May 1930, pp. 123–129, 6 figs. Data on first year of operation of Babcock boiler adapted to pulverized coal firing. Lecture before electrical section of association.

Versuche ueber Temperaturverteilung, Waermeabgabe und Verbreenungsverlauf in einem neuzeitlichen Kohlenstaubkessel), E. Kuhn. (Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates, no. 21). Berlin V.D.I. Verlag, 1930, 56 pp., diagrs., tables. 2,50 r.m. This report contains results of test of modern boiler using pulverized coal, made with unusual pre cautions to ensure results of practical value; boiler was tested during actual use; special measuring instruments and methods were devised to give accurate results; boiler and equipment and methods are described in detail, as are methods of calculations and results. Eng. Soc. Lib., N. Y.

BONUS SYSTEMS

See WAGES.

BRIQUETTING PRESSES

Cast Iron Scrap. Briquetting Cast-Iron Borings, F. J. Walls. Am. Mach., vol. 73, no. 6, Aug. 7, 1930, pp. 245–249, 7 figs. Description of design and performance of hydraulic briquetting machine built by Southwark Foundry and Machine Company of Philadelphia, and installed at plant of Wilson Foundry and Machine Company, Pontiac, Mich.; notes on use of briquets in cupola.

C

CABLEWAYS

Design. Computation of Shape of Aerial Cableways Traversed by Moving Loads (Del calcolo della configurazione delle funi portanti aeree percorse da carichi mobili), G. Piazzo. Ingegnere (Rome), vol. 4, no. 5, May 1930, pp. 312–314, 1 fig. Theoretical mathematical discussion, with numerical examples illustrating use of formulas in case of supports differing in elevation.

CADMIUM PLATING

Immersion. The Deposition of Cadmium on Small Iron and Steel Parts by Immersion, C. H. Proctor. Metal Cleaning and Finishing, vol. 2, no. 6, June 1930, pp. 491–493. General outline of procedure for applying cadmium coatings by immersion on small iron and steel parts, including such data as cleaning, acid dipping, cadmium immersion, and drying.

CARBON DIOXIDE

Refrigerant. Carbon Dioxide—Byproduct or Waste Materials. C. L. Jones. Chem. and Met. Eng., vol. 37, no. 7, July 1930, pp. 416–417. Factors affecting by-product carbon-dioxide recovery may be conveniently grouped as technological and economic factors; sound development of solid carbon-dioxide industry will depend to large extent on thoughtful and conservative handling of those supplies of by-product carbon dioxide that can be exploited on firm economic basis, and no others.

CAST IRON

Alloy. High-Quality Cast Iron in Modern Engineering Practice, A. B. Everest. Engineering (Lond.), vol. 130, no. 3365, July 11, 1930, pp. 56–58, 6 figs. Brief survey of use of alloy additions in cast iron, it is seen that wherever high strength and good wearing qualities, together with improved machinability are desired, there are strong grounds for increased application of alloy iron, and use of special elements enables foundryman to give engineer more uniform and more reliable product with improved life and service. Paper read before Rugby Eng. Soc., Jan. 15, 1930.

COAL

Carbonization, Low Temperature. Present Status of Low-Temperature Carbonization (Etat actuel de l'Industrie de la Carbonisation à basse température), C. Ab-Der-Halden. Société Industrielle de l'Est—Bul. (Nancy), no. 196, Jan.-Feb.-Mar., 1930, pp. 5–26, 6 figs. Processes that give superior value to semi-cokes; utilization of by-products; treatment of waste in coal industry and lean fuels; it is stated that low-temperature carbonization has developed its technique and equipment to great precision; utilization of by-products opens new horizons every day.

Oxygen Determination. Determination of Oxygen in Coals (Die Bestimmung des Sauerstoffs in Kohlen), F. Schuster. Gas und Wasserfach (Munich), vol. 73, no. 73, June 7, 1930, pp. 549–551, 1 fig. Report from division of chemical engineering of Berlin municipal gas works presenting critical discussion of present-day methods for determination of oxygen content of coal, with special reference to hydration methods of H. Ter Meulen and J. Heslinga.

Pulverizers. Grinding Tubes With a Simple Tube Mill, Grosse, Foerderreuther, and Rammler. Cement and Cement Mfr. (Lond.), vol. 3, no. 6, June 1930, p. 838. Investigation was undertaken to elucidate laws of grinding coal for simple tube mill and thus obtain basis for projected investigations on tube mills with air separation; mill used for tests was plysius 3 compartment mill, 28 ft. long and 4 ft. 8 in. in diam.

D

DIESEL ENGINES

Automotive. Two New Heavy-Oil Engines. Motor Transport (Lond.), vol. 51, no. 1322, July 14, 1930, pp. 64–65, 4 figs. Brief description of Blackstone and Aveling & Porter units; of former three models are made, with two, four, and six cylinders, developing 20, 40, and 60 b.hp.; cylinder dimensions of all three are 4 and 5/8 in. bore and 6 in. stroke; four cylinder Invicta engine built under Acro license is rated at 30.6 hp. and is said to develop with aluminum pistons 62.5 b.hp. at 1800 r.p.m.; fuel consumption is given at 0.44 lb. per b.hp.

Fuel Injection. Oil Spray Research Suggests Basic Factors for Designing Diesel Engine Nozzles, E. B. Neil. Automotive Industries, vol. 63, no. 2, July 12, 1930, pp. 56–61, 9 figs. Graphs show fuel aspects in oil-engine developments from papers of A.S.M.E.; relation between drop size and injection pressure; Riehm's curves for relation between dynamic pressure and penetration; N.A.C.A. curves for relation between injection pressure and penetration; relation of spray momentum to penetration; distribution of spray injected into compressed air at 200 lb. per sq. in.

High Speed. Performance of a High-Speed Compression-Ignition Engine Using Multiple Orifice Fuel Injection Nozzles, J. A. Spanogle anp H. H. Foster. Nat. Advisory Committee for Aeronautics—Tech. Notes, no. 344, June 1930, 18 pp., 26 figs. on supp. plates. Investigation to determine relative performance of single-cylinder, high-speed, compression-ignition engine when using fuel-injection valve nozzles with different numbers, sizes, and directions of round orifices; test results are presented in form of curves and chart which lists nozzles and gives dimensions of orifices and performance obtained.

M.A.N. Double-Acting M.A.N. Two-Stroke Diesel Engine in Hennigsdorf Peak-Load Power Plant Near Berlin (Die doppeltwirkenden Man-Zweitakt Dieselmotoren im Umspannwerk Henningsdorf bei Berlin), W. Laudahn. Werft-Reederei-Hafen (Berlin), vol. 11, no. 9, May 7, 1930, pp. 177–182, 11 figs. Particulars of 10-cylinder compressorless engines of 11,700 s.hp.; piston stroke, 900 mm.; speed, 215 r.p.m.; weight, 292 tons; results of tests.

Marine (Junkers). A 650 B.Hp. Engine of 1500 R.P.M. Brit. Motor Ship (Lond.), vol. 11, no. 122, May 1930, p. 79, 3 figs. Engine developed by Junkers Co. of Dessau; weight without water or oil is 1860 lb.; at 1500 r.p.m. fuel consumption is 0.365 to 0.375 lb. per b.hp.-hr.; cylinders are of new aluminum alloy known as silumin and are cast in one piece; scavenging air is supplied from turbo-blower with single impeller; motor which has 6-cylinders is totally enclosed, apart from pump gear, and cylinders are 120 mm. in diam. with piston stroke of 120 mm.

United States. Development of the Stationary Diesel in America, J. Kuttner. Gas and Oil Power (Lond.), vol. 25, no. 298, July 3, 1930, pp. 185–186. Effect of competition on progress; need for user education; costs capable of reduction; indefinite classification; private stations in majority; cost comparisons; artificial price maintenance. Abstract of paper presented before World Power Conference, Berlin.

E

ECONOMIZERS

Exhaust-Gas Utilization. Feedwater and Air Preheating by Exhaust Gases (Speisewasser und Luftvorwaermung durch Abgase), Harraeus. Feuerungstechnik (Leipzig), vol. 18, no. 9/10, May 15, 1930, pp. 84–87, 3 figs. Influence of preheating on boiler plants; exhaust-gas utilization for feedwater and air preheating; different arrangements of economizer and air preheater.

ELECTRIC FURNACES

Foundry. Automatic Regulation of Electric Furnaces in the Foundry (La régulation automatique des fours électriques de fonderie), A. Levasseur. Revue Générale de l'Electricité (Paris), vol. 27, no. 17, Apr. 26, 1930, pp. 665–670, 7 figs. Advantages of automatic regulation; variation of input power in relation to resistance; pyrometric regulation; automatic regulation of electrode furnaces.

Heat Treating. Electric Salt or Lead-Bath Furnaces (Elektrische Salzoder Bleibadoefen), H. Illies. Feuerungstechnik (Leipzig), vol. 18, no. 9/10, May 15, 1930, pp. 81–82, 3 figs. Advantages and possibilities of steel hardening in salt and lead baths; Russ electric crucible furnace; lead-bath furnace of Hoskins Electric Furnace Co.; electric pot furnace of American Electric Furnace Co.

ELECTRIC LOCOMOTIVES

Italy. Direct Current Locomotives of 3000 Volt, Series E 625 and E 626 (I locomotori a corrente continua a 3000 volt gruppi E 625 ed E 626), G. Bianchi and S. Elena. Rivista Tecnica delle Ferrovie Italiane (Rome), vol. 37, no. 5, May 15, 1930, pp. 189–250, 52 figs. and numerous figs. on 5 supp. plates. Detailed description of mechanical and electrical equipment of electric locomotives used on Foggie-Benevento line; also results of tests and operating experience; discussion of deficiencies detected and suggestions for improvements.

ELECTRIC POWER SUPPLY

Europe. Europe's Superpower Lines (Europas Grosskraftlinien), O. Oliven. V.D.I. Zeit. (Berlin), vol. 74, no. 25, June 21, 1930, pp. 875–879, 1 fig. Author proposes 400-kv. power line system embracing all countries of continental Europe and extending from Lisbon in Portugal to Rowtov in Ukrainia, and from Oslo in Norway to El Bassan in Albania; discussion of advantages of such system, geographical, climatic, and astronomical factors. Paper read at Second World Power Conference.

United States. Recent Studies in Generation and Distribution of Power, F. C. Hanker. Inst. Elec. Engrs. of Japan—Jl. (Tokyo), no. 502, May 1930, pp. 437–444. Developments of generation and transmission of electric power in United States; improvements in design of generating apparatus, factors affecting stability problem and methods for considering them in calculations. (In English.)

ELECTRIC WELDING

See also WELDING.

Arc. Graphical Analysis of Metal Transfer Processes in the Electric Arc (Ueber die graphische Zerlegung der Metalltransporvorgaenge im elektrischen Lichtbogen), P. Flamm. Elektroschweissung (Braunschweig), no. 2, Feb. 1930, pp. 27–30, 2 figs. Arc welding in time process; origin of drops is determined by experiment; of metal electrodes and their fundamentals in conditional diagram; valuation of metal electrodes.

Electrode. Electrode Research, M. Haramiishi. Welding Jl. (Lond.), vol. 27, no. 321, June 1930, pp. 174–177, 17 figs. Abstract of results of investigations of flux-coated and covered electrodes for metallic arc welding.

Flux Coatings. Influence of Flux Coated or Covered on the Metal Arc Electrode, H. Haramiishi. Am. Welding Soc.—Jl., vol. 9, no. 6, June 1930, pp. 33–46, 7 figs. Investigation of chemical change which takes place at end of tip of

electrode in metallic arc welding, using flux-coated electrode.

ENGINEERING EDUCATION

Commercial Side. The Training of an Engineer, F. W. Burstall. Engineer (Lond.), vol. 149, no. 3884, June 20, 1930, pp. 678–679; see also editorial comment, pp. 689–690. Author claims that commercial side, and more especially aspects of production are hardly touched upon in modern university course; this appears to be side of engineering teaching in universities which requires to be developed without in any way impairing value of knowledge which is entirely derived from facts of nature; at present only method by which university student can obtain practical knowledge is very limited opportunity offered to him in vacations and perhaps on short period of shop training.

Russia. Technical Training in Russia, J. G. Growther. Elec. Rev. (Lond.), vol. 106, no. 2741, June 6, 1930, pp. 1049–1050. Brief account of training methods and research activities of Electrotechnical Institute, Physico-Technical Institute, and Polytechnic Institute in Leningrad and relationships with industry and State.

ENGINEERS

Professional Status. The Engineer's Professional Status, W. E. Wickenden. Eng. News-Rec., vol. 105, no. 4, July 24, 1930, pp. 144–145. Profession has no very distinct status, is becoming more undefined as its activities broaden, and licensing has been of little service; suggests society certification of engineers. Abstract of address before Am. Soc. of Civil Engrs.

F

FEEDWATER

Analysis. Oxygen Analysis in the Boiler Room, M. E. Fitze. Power, vol. 72, no. 4, July 22, 1930, pp. 136–139, 3 figs. Description of routine followed at Lakeside Station, where analyses are made hourly of feed-water supply to each boiler.

Regulation. Automatic Boiler Feedwater Control (Ueber selbsttaetige Kesselspeisewasserregler), H. Luithlen. Sparwirtschaft (Vienna), vol. 8, no. 4, Apr. 1930, pp. 169–174, 5 figs. Float control with mechanical transmission type "Direkt" of Hanneman, Berlin; float control with electric transmission of type "Reubold" of Hanomag; equipment with hydraulic or pneumatic transmission type "Sieger of Hans Reiser and Co., Cologne, are described.

Treatment. The Use of Barium Aluminate in Water Softening, A. Seton. Eng. and Boiler House Rev. (Lond.), vol. 44, no. 1, July 1930, pp. 54 and 56. Use of barium salts in treatment of boiler feedwater; discussion of combination of barium and aluminum salts; approximate composition of commercial barium aluminate; general discussion of results of tests using various compounds.

The Treatment of Boiler Feedwater, E. P. Fager. Power Age, vol. 7, no. 7, July 1930, pp. 41–42 and 46. General discussion of proper steps to be taken in selection and treatment of feedwater.

High Pressure Feed Systems, D. G. McNair. Elec. Times (Lond.), vol. 77, no. 2017, June 19, 1930, pp. 1235–1237, 2 figs. Methods of maintaining pure, non-corrosive feed supply to high-pressure boilers.

Using Chemicals for Clarifying and Recovering Engine Condensate, A. W. Talbot and E. W. Pace. Power Plant Eng., vol. 34, no. 13, July 1, 1930, p. 746. Oil can be removed from engine condensate by means of chemical reactions which form gelatinous precipitate; only chemical reactions involved are dealt with.

Hot Lime Soda Phosphate of Feed Water for High Pressure Boilers, C. E. Joos. Combustion, vol. 2, no. 1, July 1930, pp. 19–23 and 50, 5 figs. Reasons for care in feedwater treatment; reasons for using more expensive phosphate treatment; how hot lime and soda methods meet requirements.

FLIGHT

See also GLIDING.

Birds. Note on the Wings of Gliding Birds, G. T. Walker. Roy. Aeronautical Soc.—Jl. (Lond.), vol. 34, no. 234, June 1930, pp. 495–496, 7 figs. Brief notes on gliding technique of certain birds; sketches show feather arrangement and form giving slotted wing effect.

FLOW OF FLUIDS

Hydraulic Paradox. An Hydraulic Paradox. Engineering (Lond.), vol. 129, no. 3362, June 20, 1930, p. 803. It is shown to be possible by perfectly sound and legitimate mathematical analysis to arrive at extraordinary, but impossible, conclusion that mean speed of jet of fluid may be decidedly greater than mean speed of its constituent particles; anomaly arises from fact that there are two perfectly rational, but not necessarily consistent, methods of defining velocities of flow; there is not necessarily any simple relationship between coefficients of discharge and velocities measured in nozzle tester.

Study. Application of Hydrodynamic Problem of Fluvial Hydraulics (Application de l'Hydrodynamique à l'étude d'un problème d'Hydraulique Fluviale), E. Doucet. Vie Technique et Industrielle (Paris), vol. 12, no. 129, June 1930, pp. 1367–1373, 8 figs. Theoretical study of distribution of flow velocity in rivers and sewers by means of hydrodynamic equations for viscose fluids; experiments show that theoretically derived formula is correct within 8 per cent.

FOUNDRIES

Electric Furnaces. Electric Gray Iron Entirely From Scrap, N. L. Turner. Elec. World, vol. 96, no. 2, July 12, 193 , pp. 68–69. In plant of Beach Foundry, Ltd. of Ottawa, Canada producing stove parts, point was reached where, with cupola melting, it was necessary to extend floor space to take care of production; by installing electric furnace for melting, continuous flow of iron was obtained and need of extra floor space for day's run of molds was overcome; by use of all scrap metal, cost of iron at spout has been reduced, production increased 25 to 30 per cent, and flexibility of method has been proved.

Management. How One Progressive Foundry Increased Outgoing Tonnage. Iron Age, vol. 126, no. 6, Aug. 7. 1930, pp. 341–343, 1 fig. Discussion of management policy of Standard Foundry Co., Worcester, Mass., regarding quality improvements and cost production; bonus system is illustrated by chart.

Materials Handling. Foundry Exhibition in Duesseldorf 1929 (Die Giessereifachausstellung Duesseldorf 1929). Giesserei (Duesseldorf), vol. 17, no. 25, June 1930, pp. 610–616, 15 figs. Materials handling in foundries, discussed by A. Riebold.

FUELS

Engineering. Fuel Problems Discussed at Chemical Society Meeting. Fuels and Furnaces, vol. 8, no. 5, May 1930, pp. 643–645. Abstract of papers presented before American Chemical Society; discussion of nature of carbonization and oxidation of carbonized products; mechanism of combustion of pulverized particles; cracking process; formation of hydrocarbons from water gas; gas, coke, and by-product-making properties of coal; ash-fusion-point determinations; investigation of peat humus; apparatus for analysis of carbon dioxide and oxygen.

FURNACES

Enameling. Development in Enamel Smelting Furnace Construction, R. D. Cook. Fuels and Furnaces, vol. 8, no. 5, May 1930, pp. 715–716, 3 figs. Operation of furnace, in construction of which, outside of walls and hearth were left exposed to air. Abstract of paper presented before Am. Ceramic Society.

Gas Fired. The Super Gas Furnace. Mech. World (Manchester), vol. 87, no. 2269, June 27, 1930, p. 607, 1 fig. New type of gas-fired furnace constructed by Incandescent Heat Co. is fired by patent incandescent natural-draft adjustable jet gas burners, each under separate control, working in conjunction with multi-combustion chamber system; system of gas flow ensures even heating over entire working hearth, and also prevents infiltration of cold air into chamber, thus enabling heat treatment or carburizing to be carried out with minimum of scaling.

Heat Treating. The Heat Treatment of Motorcycle Parts. Fuels and Furnaces, vol. 8, no. 8, Aug. 1930, pp. 1041–1044, 2 figs. Various types of furnaces used in heat treatment of motorcycle parts, including batch-type carburizing furnace, continuous automatic furnace used interchangeably for various kinds of heat treating, periodic furnaces for miscellaneous work, lead pots, cyanide pots, and rotary-type hardening furnace.

FURNITURE MANUFACTURE

Metal. Metal Furniture Output Expanding to Meet Wider Popular Appeal, L. Bonney. Iron Age, vol. 126, no. 2, July 10, 1930, pp. 75–77, 4 figs. Brief review of recent developments in design and construction of metal furniture.

Stainless Steel Furniture. Times Trade and Eng. Supp. (Lond.), vol. 26, no. 624, June 21, 1930, p. 354. One of directions in which newer industries have made great progress is production of stainless steel for furniture; some of uses to which it is being put at present time are: all metal furniture, more particularly for office and school use such as desks and chairs, table legs and pedestals, piano fittings, cabinet fittings, etc.

G

GALVANIZING

Continuous. Galvanizing Shops (Galvanische Werkstatt), E. Werner. Werkstattstechnik (Berlin), vol. 24, no. 11, June 1930, pp. 297–303, 3 figs. Outline of principles of construction and operation of electric galvanizing plant for mass production; data on combustion and conductivity of electrolyte sketches show washing equipment.

GEARS AND GEARING

Efficiency. Can a Machine Reverse If Its Efficiency Be Less Than 50 Per Cent? A. W. Knight. Machy. (Lond.), vol. 36, no. 927, July 17, 1930, pp. 497–499, 5 figs. Discussion of friction effects in spur and worm gears; diagram illustrating how reversal may take place when efficiency is less than 50 per cent; diagram for determining efficiency of worm gear is given.

Planetary. Planetary Gear Trains With Idler Train Arm, W. Richards. Machy. (Lond.), vol. 36, no. 926 and 929, July 10, 1930, pp. 465–469, and July 31, pp. 566–568, 9 figs. Design and calculation of planetary reduction gear; sketches illustrate gear arrangements in which driver and driven turn in opposite and in same direction with fixed and driven internal gears.

Tooth Measurement. Constant Chord Gaging. Am. Maeh., vol. 73, no. 6, Aug. 7, 1930, pp. 250–252, 4 figs. Summary of comments received on W. A. J. Chapman's article published in American Machinist, vol. 72, p. 753: V-jawed caliper can be used with existing gear tables; gear-tooth vernier is proposed to use constant chord principle without special computations.

GLIDERS

Government Regulation. The New Regulations for Glider Licensing, R. I. Hazen. West. Flying, vol. 8, no. 1, July 1930, pp. 65–66. Outline of Department of Commerce Regulations for gliders and glider pilots; no Approved Type Certificate is necessary for any light airplane with approved design if motor has less than 0.20 hp. per sq. ft. of wing surface; notes and inspection of plane and test for pilots.

Manufacture. Production of Air Gliders, J. C. Coyle. Indus. Woodworking, vol. 30, no. 11, Aug. 1930, pp. 16, 19, and 22, 6 figs. Woodworking operations included in machining, bending and fabricating of parts used in manufacture of latest type air gliders produced in Alexander Aircraft Co.'s plant.

GLIDING

Hearing. Consideration on Motorless Flight (Considerations sur Le Vol sans Moteur), A. Lafay. Génie Civil (Paris), vol. 96, no. 25, June 21, 1930, pp. 606–607, 4 figs. Importance of sense of hearing for motorless flights is discussed; sketches show microphone arrangement in wings to make air currents audible; character of sound indicates angle of incidence.

GRINDING

Duplex Wheel. Duplex-Wheel Grinding of Automobile Parts, J. M. Krings. Machy. (N. Y.), vol. 36, no. 12, Aug. 1930, pp. 958–960, 7 figs. Discussion of typical examples of duplex-wheel grinding operations performed on machines of center and centerless grinding types; data on performance, and power requirements of equipment built by Cincinnati Grinders, Inc., Cincinnati, Ohio, are given.

H

HANGARS

Braunschweig. Airplane Hangars of the Brauschweig Airport (Flugzeighallen des Braunschweiger Flughafens), H. Maushake. Stahlbau (Berlin), vol. 3, no. 11, May 30, 1930, pp. 124–127, 6 figs. Design and construction of steel-frame structures 200 m. long, 30 m. wide, with head room of 6.6 and 9.6 m.; structural details of steelwork.

Construction. Hangar Construction Simplified. Flight (Lond.), vol. 22, no. 29, July 18, 1930, pp. 804–806, 11 figs. Form of construction of novel hangar is "segmental roof" but better described as "segmental lattice" construction; hangar is 150 ft. long by 80 ft. wide; door 62 ft.

wide by 18 ft. high; advantages of this type given; may be set up temporarily or made permanent; details of framework, covering, and foundation.

Fredrichshafen. New Airship Hangar at Friedrichshafen (Die neue Luftschiffhalle in Friedrichschafen), C. Scharnow. Stahlbau (Berlin), vol. 3, no. 6, Mar. 21, 1930, pp. 61–68, 20 figs. Design and construction of steel-frame structure 248.5 m. long about 51 m. wide; framed three-hinge arch-ribs, 46 m. high, are spaced 10 m. apart; main structural features of several other similar structures in Great Britain, India, and United States.

Los Angeles. Hexagonal Hangar Feature of Western Air Express Terminal, G. N. Kramer. Airway Age, vol. 11, no. 6, June 1930, pp. 816–817, 3 figs. Facilities for housing, servicing, and maneuvering of planes; construction and auxiliary equipment; runways.

HARDNESS TESTING

Conversion Tables. New Conversion Tables Show Relations Among Hardness Tests, T. N. Holden, Jr. Iron Age, vol. 126, no. 2, July 10, 1930, pp. 80–81. Table compares hardness obtained with Rockwell using three loads, 150, 100, and 60 kg. with Brinell, diamond penetrator, and scleroscope results.

HELICOPTERS

A.L.A. The Gyroplane "A.L.A." (Il Giroplano "A.L.A."), Alfredo Varni. Ala d'Italia (Milan), vol. 9, no. 6, June 1930, pp. 529–530, 6 figs. Description of plane which is lifted by wings mounted radially in wheel-shaped frame.

Oehmichen. Helicopter Oehmichen (Helicoptere Oehmichen), E. Weiss. Nature (Paris), vol. 2835, June 15, 1930, pp. 552–556, 9 figs. Discussion of design and operation of helicopter with self-regulating propeller; notes on causes of instability.

HYDRAULIC TURBINES

Efficiency. Modern Hydroelectric Power Plants (Det moderna Vattenkraftverket), H. O. Dahl. Teknisk Tidskrift (Stockholm), vol. 60, no. 24, June 14, 1930, pp. 369–371. Mechanical equipment is discussed; hydraulic turbines, their efficiency and development.

Propeller. On the Hydraulic Efficiency of Propeller Turbines and Propeller Pumps, F. Numachi. Tohoku Imperial Univ.—Tech. Reports (Sendai), vol. 9, no. 2, 1930, pp. 231–253, 20 figs. Theoretical study of variations of hydraulic efficiency of propeller turbine and of propeller pump with respect to coefficient of peripheral velocity of rotation, coefficient of axial velocity of flow and ratio of outer diameter to inner diameter of wheel. (In English.)

Regulation. Hydraulic Turbine Governors, F. Johnstone-Taylor. Water and Water Eng. (Lond.), vol. 32, no. 378, June 20, 1930, pp. 277, and 279–281, 2 figs. General principles of automatic operation; Escher Wyss system; Woodward system; synchronizing motor or speed matcher; motor-driven ball heads.

HYDROELECTRIC POWER PLANTS

Automatic. New Nova Scotia Plant Equipped with Automatic Turbines, K. E. Whitman. Elec. News (Toronto), vol. 39, no. 13, July 1, 1930, pp. 31–34, and 44, 5 figs. Detailed description of plant at Tusket Falls, Nova Scotia.

Germany. The Schluchsee Hydroelectric Plant (Das Schluchseewerk), A. Eisenlohr. Bautechnik (Berlin), vol. 8, no. 17, Apr. 18, 1930, pp. 259–263, 14 figs. Description of hydroelectric development in Schwarzwald region in Rhine River basin, utilizing storage in natural mountain lake by means of series of tunnels; total useful head of some 600 m. utilized in three stages, developing total of 500,000,000 kw. hrs. per annum; report on construction of tunnels, small dams, power houses, etc.

The Affoldern and Bringhausen Power Plants in the Edertal Dam District (Die Kraftwerkbauten Affoldern und Bringhausen im Gebiete der Edertalsperre), K. Volk. Siemens Zeit. (Berlin), vol. 10, no. 6, June 1930, pp. 404–414, 15 figs. Description of two correlated hydroelectric plants consisting of concrete wire about 10 m. high and earth embankment 3.7 km. long, these two forming reservoirs of 2,200,000 cu. m. capacity; Bringhausen plant is of pumped storage type, water being pumped from upper end of Affoldern reservoir to an artificial reservoir, located about 300 m. above tail-water, and having capacity of 760,000 cu. m.; construction methods, electrical equipment.

Great Britain. Lead Mining under Helvellyn. Metropolitan Vickers Gaz. (Manchester), vol. 12, no. 207, June 1930, pp. 128–133, 9 figs. Object of power development has been to make most efficient use of water power available to provide for growing demand of mine for electric energy; pipe line, 21-in. bore and 1530 ft. long, conducts water to power house, where it supplies two Turgo impulse wheels, direct connected to alternators of 110 kw. and 250 kw. capacity, respectively.

Mexico. An Automatic Hydro-Electric Power Station in Mexico. Metropolitan Vickers Gaz. (Manchester), vol. 12, no. 207, June 1930, pp. 135–137, 5 figs. Function of station is to utilize available energy from variable water supply to generate electricity for supply to Necaxa, Noncolco line; two generating sets are installed one of 3800-kw. and other of 1570-kw. capacity together with automatic control gear by means of which all operations otherwise requiring skilled attention are carried out; station requires attendance only of simplest nature.

I

INDUSTRIAL MANAGEMENT

Plant Facilities. Plant Facilities, L. E. Bryant. Taylor Soc.—Bul., vol. 15, no. 3, June 1930, pp. 166–173 and (discussion) 173–181. Conditions basic to effective utilization of plant facilities are: comprehensive plan or purpose for organization, standardized conditions; interrelated or balanced equipment; knowledge of science of processing product; methods consciousness; control; supervision; definite product in definite quantities; uniform material control; payment for performance; maintenance of standards; attitude; selection of personnel; leadership.

INDUSTRIAL PLANTS

Materials Handling. Mass Production Conveyed, J. E. McBride. Black and White, vol. 2, no. 6, Aug. 1930, pp. 17, 19–22, 2 figs. Discussion of mass production in automobile industry; brief description of materials handling methods employed.

Power Costs. Power Costs in Industrial Plants and Their Calculation (Energiekosten in Betriebswirtschaft und Abrechnung), F. Landsberg. Waerme (Berlin), vol. 53, no. 25, June 21, 1930, pp. 489–492, 2 figs. Method of cost accounting to determine economy of power generation and financial aspects of power economics for enterprise as a whole.

INTERNAL COMBUSTION ENGINES

Design. Two-Stroke Engines, Some Experiments on a New Type, J. W. Robertson. Automobile Engr. (Lond.), vol. 20, no. 269, July 1930, pp. 267–272, 18 figs. Discussion of two-stroke development and characteristics; detailed description of design and performance of experimental sleeve unit; lower part of sleeve forms charging piston; 28 b.hp. per liter at 2800 r.p.m. good idling at 500 r.p.m.

Indicators. Piezoelectric Indicator for High-Speed Internal-Combustion Engines (Piezoelektricher Indicator fuer schnellaufende Verbrennungsmotoren), J. Kluge and H. E. Linckh. V.D.I. Zeit. (Berlin), vol. 74, no. 25, June 21, 1930, pp. 887–889, 9 figs. New equipment in which piezoelectric measuring of pressure is combined with system of oscillographic recording.

Vibrations. Calculation of Forced Torsional Vibrations of Multiple Mass System With Particular Regard to Internal Combustion Engines (Die Berechnung erzwungener Drehschwingungen von Mehrmassensystem en, mit besonderer Berueecksichtigung der Verhaeltnisse bei Motorenanlagen), H. Behrens. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Munich), vol. 21, no. 12, June 28, 1930, pp. 297–304, 27 figs. Formulas for reducing system with arbitrary number of masses and exciting moments to one equivalent mass and one equivalent moment; simplified solution for multi-mass system which consists of masses of same size; examples and graphs illustrate procedure.

IRON AND STEEL INDUSTRY

Japan. Japan's Steel Industry Has Become Our Best Scrap Customer Abroad, G. S. Herrick. Iron Age, vol. 126, no. 2, July 10, 1930, pp. 84–86 and 131, 5 figs. Statistical analysis of production imports and exports showing that in 1929, Japan imported 208,260 tons of steel scrap from United States alone and bought for importation only 79,875 tons of light gage black sheets.

L

LATHES

Exhibition at Leipzig. Lathes at the Leipzig Fair 1930 (Die Drehbank auf der Leipziger Fruehjahrsmesse 1930), A. Witt. Glasers Annalen (Berlin), vol. 107, no. 1, July 1, 1930, pp. 6–12, 11 figs. General notes on exhibits, standard lathes, multiple lathes, turret lathes, special automatic lathes.

LIGNITE

Drying. Operating Experiences in Drying Department of Briquet Factory and Recommendations for Control of Drying Process (Betriebserfahrungen im Trockendienst einer Brikettfabrik und Vorschlaege zur Ueberwachung des Trockenprozesses), M. Mayer and Mittelsteiner. Braunkohle (Halle), vol. 29, nos. 27 and 28, July 5, 1930, pp. 577–580 and July 12, pp. 601–608, 6 figs. General aspects for applying drying process; drying in draft without sifting; partially fractionated drying with different sifting methods.

Research. Lignite Research and Pollen Analysis (Braunkohlenforschung und Pollenanalytik), F. Kirchheimer. Braunkohle (Halle), vol. 29, no. 21, May 24, 1930, pp. 448–463, 10 figs. Microfloral, especially pollen-analytical, method as aid in lignite research is discussed. Bibliography.

LOCOMOTIVES

Germany. Theory of Steam Locomotive on Experimental Basis (Theorie der Dampflokomotive auf versuchsmaessiger Grundlage), H. Nordmann. Organ fuer die Fortschritte des Eisenbahnwesens (Berlin), vol. 85, no. 10, May 15, 1930, pp. 225–270, 79 figs. Detailed discussion of theoretical and practical basis of locomotive design; combustion problems and boiler efficiency; effect of steam pressure and degree of superheating; steam consumption and efficiency of engine; cylinder arrangement, compound arrangement, etc.; coal consumption, thermal efficiency and output characteristics of locomotive as unit.

High Pressure. D. & H. Procures Third High-Pressure Locomotive. Ry. Mech. Engr., vol. 104, no. 7, July 1930, pp. 387–393, 10 figs. Locomotive, "James Archbald," delivered by American Locomotive Co. to Delaware and Hudson; locomotive operates at boiler pressure of 500 lb.; maximum tractive force 84,300 lb.; operating single-expansion, and 70,300 lb. when working compound; driving wheels 63 in. diameter; high-pressure cylinder 20½ in. diameter and low-pressure 35½ in.; stroke 32 in.; total weight of engine 356,000 lb.

United States. On the Question of Locomotives of New Types; in Particular Turbine Locomotives and Internal Combustion Motor Locomotives (Subject V for Discussion at the Eleventh Session of the International Railway Congress Association), A. Lipetz. Int. Ry. Congress Assn.—Bul. (Lond.), vol. 12, no. 7, July 1930, pp. 1683–1700, 12 figs. Design characteristics, dimensions, and operating data of turbine and internal combustion motor locomotives; locomotives with water-tube fireboxes.

LUBRICANTS

Cutting. Machinery's Data Sheets 181 and 182. Machy. (N. Y.), vol. 36, no. 11, July 1930, p. 888A. Practice in the use of cutting fluids; number of users for each class of fluid for operations on cast iron, brass, copper, and aluminum.

M

MACHINE SHOP PRACTICE

Accuracy. Accurate Machining, F. Horner. Machy. (Lond.), vol. 36, nos. 926 and 927, July 10, 1930, pp. 457–460, July 17, pp. 500–502, 24 figs. Discussion of factor in set-up and machining which may lead to inaccuracy, and means of overcoming them; notes on foundations, shocks, distortion of machine elements, pilots; work steadiest and faults in work-holding appliances.

MACHINE TOOLS

Adjustable Foundation. Putting Up of Heavy Machine Tools (Aufstellung von Schwerwerkzeugmaschinen). Maschinenbau (Berlin), vol. 9, no. 12, June 19, 1930, pp. 406–412, 17 figs. Description of machine tools with adjustable foundation for machining of turbines and generators at Muelheim Plant of SSW.

Reducing Costs. Machine Tools From the User's Point of View, H. C. Armitage. Machy. (Lond.), vol. 35, nos. 909, 910, and 911, Mar. 14, 1930, pp. 782–785, Mar. 20, pp. 817–820, and Mar. 27, pp. 849–851, 14 figs. Mar. 14: Cost reduction by installation of new machine tools; manufacturing costs, feeds and speeds, waste handling time; capital recovery after machine purchase. Mar. 20: Bar automatics; center

lathes; drilling machines. Mar. 27: Gear-cutting machines; grinding machines; milling machines; chucking capstans and turret lathes; chucking automatics; electric welding machines. From paper read before Manchester Assn. of Engrs.

Replacment. New Equipment at the Rate of Ten Per Cent Per Year, K. H. Conduit. Am. Mach., vol. 73, no. 6, Aug. 7, 1930, pp. 229–230, 2 figs. Outline of replacement policy of Blanchard Machine Co. which provides for replacing of 10 per cent of all tools each year; performance data of typical machine tools illustrate saving.

Review. Shop Equipment Review. Am. Machinist, vol. 73, no. 3, July 17, 1930, pp. 73–147. Semi-annual résumé of machinery, tools, mechanisms, parts, and materials described in shop equipment news sections of American Machinist during first six months of 1930, and also similar résumé of Engineering Workshop equipment sections of European edition for December, 1929, to May, 1930, inclusive.

Specifications. Manufacture of Machine Tools for Wood and Metal Working (die Uebereinstimmung in der Herstellung von Werkzeugmaschinen fuer Holz- und Metallbearbeitung), W. Iwascheff. Werkstattstechnik (Berlin), vol. 24, no. 8, Apr. 15, 1930, pp. 213–214. Discussion of suggestions for accuracy of woodworking machines; comparison with metal-working machine shows need for closer tolerances.

MATERIALS HANDLING

Pneumatic. Simplified Computations for Branching Ducts and Description of Simple Device for Determination of Proper Rising Speed of Various Conveyed Materials (Vereinfachte Berechnung verzweigter Rohrleitungen, etc.), R. Karg. Gesundheits-Ingenieur (Munich), vol. 53, no. 20, May 17, 1930, pp. 305–308, 1 fig. Mathematical discussion leading to further simplification of Blaess method; outline of method of determining correct speed for pneumatic transportation of granular materials in pipes, by means of simple device, consisting of silk thread suspended in midst of riser and carrying representative particle.

Velocity of Suspended Substances and Its Determination for Pneumatic Conveying of Material (Die Schwebegeschwindigkeit und deren zuverlaessige Ermittlung fuer pneumatische Materialtransporte), H. R. Karg. Foerdertechnik und Frachtverkehr (Wittenberg) vol. 23, no. 10, May 9, 1930, pp. 191–193, 2 figs. Method for finding correct velocity for pneumatically conveyed materials is described.

Survey. Handling Is Never so Good It Can't Be Made Better, A. W. Leet. Factory and Indus. Mgmt., vol. 80, no. 2, Aug. 1930, pp. 274–276, 5 figs. Engineering survey and consequent coordinated transportation plan are described here; by using existing equipment and methods, there resulted savings which soon paid for survey and for new equipment required.

METALS

Age Hardening. Age-Hardening, M. L. V. Gayler. Metallurgist (Supp. to Engineer, Lond.), June 1930, pp. 91–93. Of theories put forward to explain age hardening, one which has gained most ground is precipitation theory which attributes age hardening to precipitation, in highly dispersed state, of particles from supersaturated solid solution; facts which have been established regarding changes which take place during age hardening are strong confirmation that hardening is due to precipitation of highly dispersed particles.

Corrosion Testing. New Process for Simultaneous Corrosion Testing of Different Metals (Ein neues Verfahren zur gleichzeitigen Korrosionskurzpruefung verschiedener Metalle), G. Gollnow. Giesserei (Duesseldorf), vol. 17, no. 27, July 4, 1930, p. 665, 2 figs. Details of electric process and equipment for measurement of corrosion of metals in solutions, developed by Toedt.

Fatigue. Fatigue Strength and Tensile and Rupture Strength, W. Kuntze. Metallurgist (Supp. to Engineer, Lond.), June 1930, pp. 94–95. According to author rupture streagth plays important part in fatigue phenomena; this property is defined as tensile strength when all deformation is prevented; procedure is to measure breaking tensile stress of number of specimens having circular notches of different depths and to extrapolate curve of maximum stress against area at base of notch to zero area. Translated abstract previously indexed from V.D.I. Zeit., Feb. 22, 1930.

Flow. Flow Pressure of Metals and Alloys at Various Temperatures, V. P. Shishokin. Tzvetniye Metalli (Moscow), no. 5, May 1930, pp. 662–671, 4 figs. Results of experimental study of flow pressure of metals having low melting point, including tin, lead, cadmium, bismuth, etc.; empirical law of variation of flow pressure with temperature is derived; temperature coefficient of flow pressure is numerically equal to temperature coefficient of Brinell hardness. (In Russian.)

METAL SPRAYING

Schoop Process. Schoop's Metal Spraying Process in a New Form (Schoops metalliseringsmetod i ny form), A. Salmony. Teknisk Tidskrift (Stockholm), vol. 60, no. 24, June 14, 1930, pp. 375–376, 4 figs. Apparatus for metallizing objects by spraying melted and carburized metal is described, apparatus was invented 26 years ago but is now greatly improved.

MOLDING MACHINES

Foundry. Methods of Moulding Castings for Stoves, Heating Apparatus, and Various Builders' Castings, H. Magdelenat. Foundry Trade Jl. (Lond.), vol. 43, no. 725, July 10, 1930, pp. 24–27, 10 figs. Description of methods of molding pedestal stove, certain cooking range parts, skylight frame and sink; plan and elevation of Rosieres-Bachon continuous molding machine lay-out; notes on sand preparation; labor; production and wages.

Rational Non-Ferrous Foundry Practice [Rationelle Metallgiesserei Praxis—Das kastenlose Formen (Amerikaguss)]. Zeit. fuer die Gesamte Giessereipraxis (Berlin), vol. 51, no. 26, June 29, 1930 (Metall), pp. 105–107, 11 figs. Flaskless molding practice is discussed.

MOTORSHIPS

Diesel (Britannic). The "Britannic." Brit. Motor Ship (Lond.), vol. 11, no. 124, June 1930, pp. 124–157, 74 figs. Detailed description of vessel, brief account of which was indexed from Jan. 1930, issue of same journal.

MOTOR TRUCKS

Tipping Gears. Motor Trucks and Trailers With Dump Bodies at the Spring Fair in Leipzig in 1930 (Lastkraftwagen und Anhaengerkipper auf der Leipziger Fruehjahrsmesse 1930), P. Schroeder. Foerdertechnik und Frachtverkehr (Wittenberg), vol. 23, no. 11, May 3, 1930, pp. 209–216, 19 figs. Description of arrangement and mechanism of tipping gears operated by hand, mechanical, and hydraulic power.

N

NATURAL GAS WELLS

Pressure Regulation. Practical Pressure Regulation, T. H. Beals. Natural Gas, vol. 11, no. 6, June 1930, pp. 14–15 and 56. Importance of pressure control; types of well pressure-control devices; classification of regulation; difficulties encountered in effort to obtain proper regulation. Paper read before Southwestern Gas Measurement Short Course.

O

OIL ENGINES

Hesselman. Low-Pressure High-Speed Oil-Engine. Engineer (Lond.), vol. 150, no. 3887, July 11, 1930, pp. 45–47, 7 figs. New engine utilizing non-volatile fuels has been invented and developed by K. J. E. Hesselman; principal feature is that, while working with low compression and ignition pressure, it retains ordinary spark ignition and many features of normal gasoline-engine construction, but principle employed enables heavy oils to be used with considerable saving in cost of fuel; typical performance results.

Ruston. A New "Ruston" Crude-Oil Engine. Machy. Market (Lond.), no. 1549, July 11, 1930, p. 19, 3 figs. Brief description and sketches of gas and oil engine starting instantly from cold, running on 0.47 lb. per b.hp. hr. in smallest to 0.40 lb. in largest sizes; one- and two-cylinder types are made from 10 to 66 hp.

OIL WELL DRILLING

Core. Orientation of Cores, G. A. Macready. Am. Assn. of Petroleum Geologists—Bul., vol. 14, no. 5, May 1930, pp. 559–578, 11 figs. Orientation of cores should be of great value in geological investigations of subsurface structures; historical development of orientation of cores since early German method of seventies is reviewed, recent California practice is touched on, and investigations by writer since 1918 are described. (Bibliography.)

Deep. Review of Drilling Below 5000 Feet in West Texas, R. A. Jones. Oil Weekly, vol. 57, no. 12, June 6, 1930, pp. 28–30, 110, 112, and 114, 1 fig. Important features of University 1-B completed at depth of 8525 ft.; production of well; geology of section, tests below 5000 ft.

Diesel Engines. Diesel Engine Drills Deepest Cable Tool Well. Oil Field Eng., vol. 8, no. 1, July 1930, pp. 30–31, 3 figs. Using gas oil as fuel, consumption has been held below 42 gal. per day with one type of Diesel engine while second varied from 30 to 50 gal. per day.

Equipment. Largest Electric Drilling Equipment in Oklahoma City Field, W. A. Sawdon. Oil Field Eng., vol. 8, no. 1, July 1930, pp. 18–19 and 39, 4 figs. Importance of calibrating ammeters; results of test made on electric power consumption and time taken in pulling out from depth of 3160 ft. in hall and Brisco well Lindsey No. 1.

P

PAINT

Testing. Practical Test for Determining the Hiding Power of Paints, H. A. Gardner, G. G. Sward and S. A. Levy. Metal Cleaning and Finishing, vol. 2, no. 6, June 1930, pp. 537–538. Outline of method of determining hiding power of paint by brushing out paint upon surface of checkerboard linoleum made up of black and white blocks. Abstract of paper presented before Am. Soc. Testing Matls.

PATENT LAW

United States. Extent of Permissible Monopoly in Patents, L. T. Parker. Power Plant Eng., vol. 34, no. 10, May 15, 1930, pp. 573–574. Review of present laws and high court decisions involving rights of patentees.

PETROLEUM INDUSTRY

Russia. Five-Year Plan for the Development of the Petroleum Industry of U.S.S.R. Gorniy Journal (Moscow), vol. 105, no. 10, Nov. 1929, pp. 1671–1702. General review of present status of petroleum industry in Russia with special reference to available resources, exploration, and new drilling, production of petroleum and natural gas; petroleum refining; financial problems, scientific management of petroleum industry; cost data. (In Russian.)

PETROLEUM REFINING

By-Products. Petroleum Residuals and By-Products, A. E. Dunstan. Petroleum Times (Lond.), vol. 23, no. 598, June 28, 1930, pp. 1123–1126. Discussion of utilization of acid sludge, petroleum coke, asphalt residues, and waste gases for power purposes. Abstract of paper read before Second World Power Conference, at Berlin.

Edeleanu Process. Anti-Knock Motor Fuel, L. Edeleanu and W. Grote. Petroleum Times (Lond.), vol. 23, no. 568, June 28, 1930, p. 1148. Advantages of use of liquid sulphur dioxide in refining are stressed; summary of results of experiments with motor fuels of different origins; authors point out that character of cracked gasoline and properties of crude oil from which it originates are important in determining quality of products prepared by their method; where high-boiling fraction over 175 deg. cent. is high in aromatics, anti-knock value of resulting motor fuel will be higher. Abstract translated from Brennstoffchemie, June 1, 1930.

PHOTOELECTRIC CELLS

Applications. Automatic Control With Photo-Electric Cells, E. H. Vedder. Elec. Jl., vol. 27, no. 7, July 1930, pp. 407–410, 12 figs. Application of light relay other than automatic control in industry is outlined; examples of controlling light in factory; photo-cell indications of breakage in paper manufacture, flashover protection of electric generators, automatic counting etc. are given.

Photoelectric Cell and Its Applications (La cellule photoélectrique et ses applications), L. Dunoyer. Technique Moderne (Paris), vol. 22, nos. 4, 5 and 6, Feb. 15, 1930, pp. 137–144, Mar. 1, pp. 179–182 and Mar. 15, pp. 212–219, 37 figs. Manufacture and properties of photoelectric cells; measurement of photoelectric currents; application of photoelectric cells in telephotography, television, sound, and talking picture practice.

PIG IRON

Hematite. Change in Properties of Hematite Pig Iron Cast in First Charge (Aenderung der Eigenschaften des in erster Schmelzung vergossenen Haematitroheisens), E. Piwowarsky.

Stahl und Eisen (Duesseldorf), vol. 50, no. 27, July 3, 1930, pp. 966–968. Temperature losses during transport of ladle from blast furnace to mixer; changes in chemical composition and strength are traced up to finished product; difference in behavior of specimens cast in chill and in sand.

PIPE

Centrifugal Casting. Chemical Composition and Mechanical Properties of Centrifugal Castings, J. E. Hurst. Metallurgia (Lond.), vol. 2, nos. 7 and 8, Mar. 1930, pp. 13–16 and June, pp. 54–56 and 53, 11 figs. May: Applications of centrifugal casting, to pipe and to drums and cylinders for piston rings, cylinder liners, etc.; British Eng. Standards Assn. Specification as to chemical composition; distribution of constituents; tendency to segregations; microstructure; mechanical properties; data on bursting, collapsing, bending, tensile, and transverse tests. June: Impact tests; Brinell hardness; sand-spun pipe; piston ring and cylinder testing.

POWER PLANTS

Diesel-Electric. Influence of Peak-Load Plants on Economy of Large Power Plants (Einfluss Spitzenkraftwerken auf die Wirtschaftlichkeit von Grosskraftwerken), M. Gercke. Waerme (Berlin), vol. 53, no. 24, June 14, 1930, pp. 482–485, 1 fig. Economy in use of peak-load Diesel engines is illustrated by results obtained in number of German plants; influence of separation of basic and peak load and economic effect of absorption of peak load with special regard to use of Diesel engines are discussed based on American and German studies.

Diesel Power Replaces Steam at Public Utility Plant. Power Plant Eng., vol. 34, no. 15, Aug. 1, 1930, pp. 865–866, 3 figs. Low repair cost characterized operation of Consolidated Public Utility Co.'s plant; installation uses pressure lubrication; low repair record.

Steam vs. Hydroelectric. Hydro Yields to Steam on Economic Grounds, F. B. Lewis. Elec. World, vol. 95, no. 25, June 21, 1930, pp. 1298–1299, 1 fig. At zero load factor annual cost of steam power is less than that of water power; under steam-plant efficiencies and fuel costs obtainable some years ago, additional output expense of steam production, with increased load factor, caused total steam costs to exceed water-power costs, except at relatively small load factors.

Cheap Steam Power Checks Hydro-Expansion, A. H. Markwart. Elec. World, vol. 95, no. 25, June 21, 1930, pp. 1271–1273, 2 figs. Present trend of water-power development costs is upward, because as general thing remaining sites cost more to develop and are less accessible than those sites which have already been developed; influence of price of oil; natural gas going to waste; whole economic trend is toward 100 per cent steam for new installations, unless some very favorable hydro present itself.

POWER TRANSMISSION

Group Drive. Group Drives, J. R. Hopkins. Power Plant Eng., vol. 34, no. 14, July 15, 1930, pp. 820–821. Advantages in economy, effect on peak load, and power factor; belts should have ample capacity.

Short Center Drive. Power Transmission With Center Drives, R. Salmonsen. Power Plant Eng., vol. 34, no. 41, July 15, 1930, pp. 817–820, 5 figs. Details, speeds, and efficiencies of silent chain, V-belt, and flat belt.

PUMPS, CENTRIFUGAL

Corrosion. Corrosion in Centrifugal Pumps, C. H. S. Tupholme. Power Plant Eng., vol. 34, no. 10, May 15, 1930, pp. 571–572. Discussion of chemical, mechanical, and electrolytic changes which cause trouble.

PUMPS, FEEDWATER

Centrifugal. Centrifugal Feed Pumps for High-Pressure Boilers (Kreiselpumpen zum Speisen von Hochdruckkesseln), G. Weyland V.D.I. Zeit. (Berlin), vol. 74, no. 15, Apr. 12, 1930, pp. 467–471, 14 figs.; see also brief translated abstract Power Engr. (Lond.), vol. 25, no. 292, July 1930, pp. 287–288. Stress is laid on importance of reliability in feed pumps for extra-high-pressure boilers; circulating pump, used in Mannheim plant to circulate water through superheater during starting period until steam is available from boiler, can be subjected to pressures up to 100 atmos. and temperatures to 310 cent.; it runs at 1450 r.p.m. and delivers 40 tons per hr.

Centrifugal Pumps (Kreiselpumpen), G. Weyland. Waerme (Berlin), vol. 53, no. 24, June 14, 1930, pp. 473–481, 29 figs. Their application to feed of superpressure boilers is discussed; economic advantages of high feedwater preheating; proper design of hot-water pumps; necessity of reliable feedwater pumps for superpressure boilers, and experiences with such pumps; heating of feed water by flow through pump; condensate return to boiler without any special pump.

Turbine. Centrifugal Feed Pumps for High-Pressure Boilers, G. Weyland. Engineer (Lond.), vol. 149, no. 3883, June 13, 1930, pp. 666–667, 10 figs. Details of turbine-driven pump which automatically comes into operation when electrically driven pump working in conjunction with it is stopped; characteristics of 10-stage Klein Schanzlin and Becker pump with different blades, both designed for same maximum output at highest pressure; turbine-driven feed pump for hot water with output of 180 to 240 metric tons per hr. from Mannheim power station, and turbine, and motor-driven pump built for Benson boiler installation at Berlin Gartenfeld works of Siemens-Schuckert Co.

PULVERIZED COAL

Combustion. Pulverised-Fuel Problems, L. K. Ramzin. Iron and Coal Trades Rev. (Lond.), vol. 121, no. 3256, July 25, 1930, p. 127. Pulverized combustion affords greatest economy of fuel; non-caking fuels with high content of volatile matter would be burnt to most advantage in pulverized form; profitability of powdered fuel furnace tends to increase smaller content of volatile matter in fuel; relative merits of centralized and unit systems of pulverized-fuel firing.

Dust Problem. Coal-Dust Problem (Betraege zur Kohlenstaubfrage), F. Prockat. Glasers Annalen (Berlin), vol. 106, nos. 8 and 12, Apr. 15, 1930, pp. 93–97 and June 15, pp. 151–154, 14 figs. Mathematical analysis; blow tests with coal dust; precipitation of dust, analysis of grain size, surface formation of coal, and absolute determination of surface; blow tests with slate, coal, and mixtures of both.

PULVERIZED COKE

Properties. Pulverizing Properties of Coke in Relation to Its Tar Content (Die Mahlbarkeit des Schwelkokses in Abhaengigkeit von seinem Teergehalt), Rosenthal. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 5, May 1930, pp. 169–172, 9 figs. Influences which govern pulverization are discussed, including influence of grain size, water content, and hardness; laboratory tests show that friability of coke depends upon tar residue content.

PULVERIZED LIGNITE

Drying. Preparation of Pulverized Lignite With Pneumatic Circulation Drying (Herstellung von Braunkohlenstaub mit der pneumatischen Umlauftrocknung), P. Rosin and E. Rammler. Braunkohle (Halle), vol. 29, no. 26, June 28, 1930, pp. 557–563, 11 figs. Circulation drying is pneumatic process according to which transport and drying of wet products in suspension are effected by hot gases which circulate at high speed through pipe system; details of circulating drier.

PRESSURE VESSELS

Welding. See WELDING.

R

RADIO BEACONS

France. Radio Beacons of Bobigny for Aerial Navigation (Le radiophare de Bobigny pour la navigation aérienne), M. Clériot. Aéronautique (Paris), no. 133, June 1930, pp. 221–226, 12 figs. Radio beacons for aviation are new in France; article, after outlining general principles, characteristics, intensity of reception, sensitivity, and stability, etc., gives detailed description of 1-kw. beacon in Bobigny 5 km. from Bourgert, employing 7 amp. in antenna.

RAILROAD REPAIR SHOPS

Toolroom Practice. Equipment and Methods in a Modern Railroad Tool Room, L. M. Jordan. Railroad Herald, vol. 34, no. 6, May 1930, pp. 21–23, 2 figs. Brief discussion of modern equipment and methods employed in Sacramento General Shops of Southern Pacific Railroad, at Sacramento, California.

REFRACTORY MATERIALS

Abrasion Testing. A Progress Report on the Development of an Abrasion Test for Refractories at High Temperatures, J. B. Shaw, G. J. Bair, and M. C. Shaw. Am. Ceramic Soc.—Jl., vol. 13, no. 7, July 1930, pp. 427–436, 8 figs. Method developed consists of steel chisel point moving back and forth over faces of brick clamped together; eleven bricks are tested at one time; chisel is actuated by means of jack hammer and is watercooled; data show that principle is correct and capable of differentiating between brick of varying resistances to abrasion at temperatures as high as 1350 deg. cent.

REFRIGERATING PLANTS

Temperature Regulation. Temperature Conditions in Automatic Refrigerating Plants (Temperaturverlauf in automatisch gesteuerten Kuehlanlagen), S. Jung. Zeit. fuer die gesamte Kaelte-Industrie (Berlin), vol. 37, no. 6, June 1930, pp. 101–110, 11 figs. Report of investigation undertaken to determine sensitivity and efficiency of temperature-regulating instruments for refrigerating plants; numerous existing plants were investigated and results are discussed.

ROCKET PROPULSION

Efficiency. Propulsion by Reaction, M. Roy. Nat. Advisory Committee for Aeronautics—Tech. Memorandum, no. 571, June 1930, 19 pp., 4 figs. Mathematical investigation of efficiency of propulsion systems of rocket and propeller type; sketch shows propeller arrangement with reaction nozzles at tips of blades. From Technique Aéronautique, Jan. 15, 1930.

S

SEAPLANES

Landing. Theory of Landing Shock of Seaplanes (Theorie des Landestosses von Seeflugzeugen), W. Pabst. Zeit. fuer Flugtechnik und Motorluftschiffahrt (Muenchen), vol. 21, no. 9, May 14, 1930, pp. 217–226, 14 figs. Brief review of physical laws applicable to landing in waves; experimental determination of accelerated mass of water; mathematical analysis of conditions with flat-bottom pontoons; discussion of pontoons with keel; graphs show effect of keel angle on impact and other relations.

Landing on Ice With Pontoon Equipped Plane (Naogot om Islandning med Flottoerflygplan). Flygning (Stockholm), vol. 8, no. 6, June 1930, pp. 128–129, 2 figs. Brief analysis of forces induced by landing shock and notes on strength of pontoon structure.

SHAFTS AND SHAFTING

Design. Approximate Calculation of Shaft (Die Ueberschlaegliche Berechnung von Wellen), W. Vogel. Werkstattstechnik (Berlin), vol. 24, no. 11, June 1930, pp. 304–306, 1 fig. Justification and need of approximate method of computation is discussed; compilation of formulas in tabular form; chart is given which permits reading of diameter of shaft for any torque.

SHEET METAL WORKING

Drill Jigs. Applications of Drill Jigs to Metal Stampings, C. Szalanczy. Metal Stampings, vol. 3, no. 7, July 1930, pp. 655–658, 5 figs. Typical single and multiple drill jigs used to advantage in metal stamping plants for production of small diameter holes.

Welding. Gas-Welded Sheet Metal Products. Welding, vol. 1, no. 9, July 1930, pp. 619–622, 9 figs. Use of welding in manufacture of hospital equipment, metal furniture, metal doors, and sash, steel barrels, sheet metal in airplane manufacture, and for other types of products.

SMOKE ABATEMENT

Observations. Behavior of Humid Air in Motion (Das Verhalten feuchter Luft in Bewegung), R. Schwanda. Gesundheits-Ingenieur (Munich), vol. 53, no. 15, Apr. 12, 1930, pp. 225–227, 1 fig. Observations of certain paradoxical phenomena in action of smoke condensers; explanation attempted and further lines of research indicated.

Fighting the Smoke Evil, F. Goodenough. Gas Jl. (Lond.), vol. 191, no. 3502, July 2, 1930, pp. 30–31. Brief account of contribution of gas industry to elimination of smoke nuisance. Abstract of presidential address before Roy. Sanitary Inst. Congress.

Smoke, Causes, Inconveniences, Remedies (La Fumée, Causes Inconvénients, Remèdes), Varinois. Revue Industrielle (Paris), vol. 60, no. 2249, Apr. 1930, pp. 230–237, 3 figs. Notes on corrosion resulting from chimney gases; tables showing smoke conditions in Chicago in 1912; action of smoke on stone, and metal, on vegetation, influence on health, economic aspects, carbonization, injection of secondary air, etc. Bibliography.

STEAM

High Pressure. High Pressure and Highly Superheated Steam in Power Plants (Hochgespannter und hochueberhitzer Dampf in Kraftanlagen), Marguerre. V.D.I. Zeit. (Berlin), vol. 74, no. 24, June 14, 1930, pp. 789–797, 26 figs. Economic aspects of high-pressure steam in back-pressure and condensation installations; influence of initial steam temperature and problem of inter-

mediary heating; problems of design and operation of high-pressure boilers; standard designs and special designs of boilers; feed pump engines; high-pressure locomotives. Paper read before World Power Conference, Berlin.

STEAM ACCUMULATORS

Kiesselbach. Combined Constant-Pressure and Precipitation Accumulators for Load Equalization in Steam Power Plants (Gekuppelter Gleichdruck- und Gefaellespeicher fuer Belastungsausgleich in Dampfkraftwerken), L. Oelschlaeger. Waerme (Berlin), vol. 53, no. 24, June 14, 1930, pp. 469–472, 7 figs. Advantage of combining these two types of accumulators is exemplified; connection and operation of combined Kiesselbach accumulator are described.

STEAM-ELECTRIC POWER PLANTS

Peak Loads. Extension of Charlottenburg Plant to Peak-Load Plant (Ausbau des Kraftwerks Charlottenburg zum Spitzenwerk), W. Stender and E. Frank. Siemens Zeit. (Berlin), vol. 10, no. 6, June 1930, pp. 369–376, 11 figs. Extension is to provide for peak load of Berlin network to extent of 40,000 kw. during 3 hours and 67,000-kw-hr. total supply; 16 Ruth accumulators of 5000 cu. m. and storage capacity of 610 kg.-tons of steam at 0.5 to 16 atm. are installed; description of equipment, wiring diagrams, etc.

STEAM POWER PLANTS

Ash Handling. Ash Handling in Boiler Rooms (La Manutention des Cendres dans les Chaufferies), M. Boulvin. Anales de l'Association des Ingenieurs Sortis Des Ecoles Spéciales De Gand (Ghent), vol. 19, 1929, pp. 307–330, 22 figs. General description of systems, with special regard to mechanical and continuous methods.

Fuel Economy. Fuel Economy as a Function of Financing and Operating Economy (Waermewirtschaft als Teil der Finanz und Betriebswirtschaft), F. Wartenberg. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 5, May 1930, pp. 153–156, 4 figs. Commercial and technical aspects of fuel economy in relation to plant management; it is claimed that very small plants do not require high-salaried manager; but for larger plants, employment of heat engineer will probably prove profitable; functions of heat engineer are outlined.

Heating and Power. Reducing the Heating System's Steam Consumption, C. L. Hubbard. Power, vol. 72, no. 7, Aug. 12, 1930, pp. 253–254, 3 figs. Methods are suggested for reduction of steam supply for building heat; diagrammatic layouts of power plant combined with heating system are illustrated and described.

High Pressure. High-Pressure Steam for Power and Process at Billingham. Power Engr. (Lond.), vol. 25, no. 292, July 1930, pp. 261–279, 33 figs. and supp. plate; see also editorial comment on pp. 253–254. Outline of large and important extension plant of Synthetic Ammonia and Nitrated, Ltd., at Billingham-on-Tees; general illustrated description of equipment and piping is given; plant-layout prints are also included.

Lignite Fired. Operation of Lignite Plant and Central Station at Boehlen (Aus dem Betrieb des Braunkohlen und Grosskraftwerkes Boehlen), H. Zeuner. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 5, May 1930, pp. 157–162, 7 figs. Description of lignite briquetting plant and power station; utilization of vapors from briquet-plant driers for recovery of water for boiler operation; utilization of flue gases as protection against explosions in pulverizing plant; operating experiences with pulverized-coal-fired boilers; measuring instruments and electric equipment.

Pulverized Coal Fired. Description of New Steam Generators at Derby Station, D. Brownlie. Combustion, vol. 2, no. 1, July 1930, pp. 36–38 and 48, 7 figs. Station is cited as notable example of comparatively small plant that embodies very latest practice throughout; boiler plant, including two new units; has total capacity of approximately 400,000 lb. of steam per hr.; five pulverized fuel-fired units occupy same aggregate floor space previously occupied by eleven stoker-fired units, but have nearly double steaming capacity.

Waste Elimination. Eliminating Waste in a Small Plant, H. C. Dinger. Power, vol. 72, no. 7, Aug. 12, 1930, pp. 242–243. Results obtained in power plant of Naval Engineering Experiment Station prove that economies in operation need not be confined to large plants.

STEAM TURBINES

Design. Recent Large Steam Turbines (Neuere Grosse Dampfturbinen), K. Baumann. V.D.I. Zeit. (Berlin), vol. 74, no. 24, June 14. 1930, pp. 805–832, 19 figs. Review of development and discussion of important factors of design; data on reliability, operating conditions, and losses; typical makes of large steam turbines are described. Paper read before World Power Conference, Berlin.

Design Problems of Ideal Turbines (Die Grenzturbine als Gestaltungsproblem), E. A. Kraft. Maschinenbau (Berlin), vol. 9, no. 12, June 19, 1930, pp. 401–405, 10 figs. Importance of proper dimensioning of last stage is discussed; description of designs of disks 2000 mm. in diam. at 3000 r.p.m.; data on efficiency of turbine gears.

Starting Speed, Operating Safety, and Economy of Steam-Turbine Units (Betriebsbereitschaft, Betriebsicherheit und Wirtschaftlichkeit der Dampfturbosaetze), M. Blaensdorf. Waerme (Berlin), vol. 53, no. 27, July 5, 1930, pp. 521–524, 7 figs. These three factors which have influenced design of steam turbines to greatest extent, are discussed, and examples are given showing how these properties have been effected in large modern turbine sets; one of largest in Europe has attained efficiency of 87.7 per cent.

Failures. Steam Turbine Failures. Engineer (Lond.), vol. 150, no. 3888, July 18, 1930, p. 64. Brief account of four cases of failure cited by Vulcan Boiler and General Insurance Co. in their house journal.

High Pressure. Turbines for High Pressure Industrial Plants of the Future, I. H. Melan. Power Plant Eng., vol. 34, no. 14, July 15, 1930, pp. 804–806, 4 figs. Advantages of turbines for pressures up to 3200 lb.; simplicity, safety, ease of control, and extraction and high efficiency; three-dimensional graphs of turbine efficiency, which is function of Parsons characteristic and steam flow.

STEAMSHIPS

Turbine (Bremen). The Propelling Machinery of the North German Lloyd Liner Bremen, P. Biedermann, H. Hein, and W. Koch. Engineer (Lond.), vol. 149, no. 3884, June 20, 1930, pp. 684–685, 12 figs. partly on p. 688. Details of engine-room auxiliary machinery; main and auxiliary condensing plant; lubricating arrangement; boiler-feed arrangements; evaporators and auxiliary pumps; service results. (Concluded.) Abstract translated from V.D.I. Zeit., special Bremen issue, May 24.

STEEL

Heat Treatment. Heat Treatment of Steel and Use of Special Steel in the Machine Industry (Om Varmebehandling av Stal), N. H. Aall. Teknisk Ukeblad, vol. 77, no. 27, July 3, 1930, pp. 304–306. Discussion of plain carbon steel vs. alloy steel with regard to satisfactory control of physical properties by proper heat treatment; ratio of chilling speed to crystallization speed permits conclusions as to whether carbon or alloy steel is more economic.

The Effect of the Rate of Cooling on Steel, J. M. Robertson. Chem. Age (Lond.), vol. 23, no. 575, July 5, 1930 (Met. Sec.), pp. 1–2. Discussion of accepted theories of effect of heat treatment on steel; original theory of relations of martensite, troostite, and sorbite to each other and to normal iron-carbon diagram; four series of structures obtained by different methods of cooling.

STOKERS

Lignite Fired. High-Duty Stoker for Slow-Burning Fuels (Hochleistungsrost fuer schwer zuendende Brennstoffe), Berner. Waerme (Berlin), vol. 53, no. 24, June 14, 1930, pp. 431–433. New firing system, developed by Arbatsky, for lignite, is described with which, by acceleration of drying and ignition, specific grate efficiency of 2.75 million kg-cal. per sq. m.-hr. is obtained, and output of 125 tons per hr. of steam.

Peat Firing. Mechanical Stokers for Burning of Peat, N. M. Savellov and N. A. Semenenko. Izvestiya Teplotechnicheskovo Instituta (Moscow), no. 1 (54), 1930, pp. 32–57, 29 figs. Report to All-Russia Thermo-Technical Convention treating of peat as fuel and describing design and operation of three classes of mechanical and semi-mechanical stokers, developed in Russia; results of tests presented in tabular form. (In Russian.)

Underfeed. Firing of Tertiary Bituminous Coal on Underfeed Stokers (Verfeuerung tertiaerer Bitumenkohlen auf Unterschubrosten), B. Kretzschmar. Archiv fuer Waermewirtschaft (Berlin), vol. 11, no. 5, May 1930, p. 168. Notes on properties and firing of coals from Dutch East Indian islands, Borneo, and Sumatra; these coals have high gas and water content, and are very soft; experiences with burning this coal on underfeed stokers under water-tube boilers on ships of Royal Dutch line.

Waste Fuel. Burning Waste Fuel With Underfeed Stokers, R. A. Foresman and D. J. Mosshart. Power Plant Eng., vol. 34, no. 15, Aug. 1, 1930, pp. 860–861, 2 figs. Bark, wood waste, coke breeze, and other fuels can be handled easily in underfeed stokers.

SUPERHEATERS

For High Temperatures. Superheaters for High Steam Temperatures (Ueberhitzer fuer hohe Dampftemperaturen), O. H. Hartmann. Waerme (Berlin), vol. 53, nos. 24 and 27, June 14, 1930, pp. 463–468, and July 5, pp. 525–528, 19 figs. Experiences with stationary plants in Germany and other countries: superheater requirements; practical tests with new materials; directly heated superheaters.

T

TUNGSTEN CARBIDE CUTTING TOOLS

Carboloy. Carboloy Tools at the White Motor Plant. Machy. (N. Y.), vol. 36, no. 12, Aug. 1930, pp. 980–982, 5 figs. Typical applications of carboloy at White Motor Co. plant are discussed; data on increased life of tool and savings made possible by use of carboloy.

Widia. Practical Uses of Widia Tool Metals (Widia-Werkzeugmetall in der Technik), A. Fehse. Werkstattstechnik (Berlin), vol. 24, no. 9, May 1, 1930, pp. 237–244, 40 figs. Description of experiences made in use of Widia tool metal plates and tips; application to various kinds of tools is illustrated.

W

WAGES

Payment Plans. A Successful Bonus System in the Tool-Room, W. C. Betz. Machy. (N. Y.), vol. 36, no. 12, Aug. 1930, pp. 938–939. Outline of bonus system used for six years in tool room of Fafnir Bearing Co., New Britain, Conn.

WASTE ELIMINATION

Plants. Eliminating Unnecessary Waste in Plant Operation, J. J. Berliner. Metal Stampings, vol. 3, no. 7, July 1930, pp. 613–616 and 652. Importance of managerial control, close supervision, and other factors for eliminating unnecessary waste of materials and labor.

WATER TREATMENT

Neutralization. Graphics of Neutralization of Water Acidity (Betrachtungen ueber die Entsaeuerung des Wassers an Hand graphischer Darstellungen) P. Martiny. Gesundheits-Ingenieur (Munich), vol. 53, no. 25, June 21, 1930, pp. 395–396. Table and explanatory discussion supplementary to previously indexed article published in issue of Mar. 29.

WELDING

Aircraft. Procedure Control for Aircraft Welding, H. L. Whittemore, J. J. Crowe, and H. H. Moss. Welding, vol. 1, no. 9, July 1930, pp. 589–590 and 595, 3 figs. Discussion of specifications for material and apparatus used; ability of operator; technique used in each operation; inspection of finished product; brief abstracts of Procedure Control for Welding Aircraft Joints—Report by Committee of American Bureau of Welding.

Plant Repairs. Welding in Plant Repairs, H. W. Benton. Power Plant Eng., vol. 34, no. 15, Aug. 1, 1930, pp. 886–888, 4 figs. Use of right methods and equipment by experienced operators cut costs in manufacture and plant upkeep; welding vs. riveting.

Pressure Vessels. Welding of Super Code Pressure Vessels, L. H. Burkhart. Am. Welding Soc.—Jl., vol. 9, no. 6, June 1930, pp. 28–32, 3 figs. Welding procedure for vessels larger than 60 in. diam. for more than 200 lb. pressure and which may employ unit stress more than 8000 lb. per sq. in. of weld section: results of tests of procedure.

Gas-Welding of Heavy Plate Construction, O. A. Davis. Welding, vol. 1, no. 10, Aug. 1930, pp. 693–696, 6 figs. Discussion of advantages of oxyacetylene welding in making lime kilns, pressure vessels, creosoting tanks, etc.; methods and equipment of A. G. Reeves Steel Constrtction Co., Alliance, Ohio.

WOOD PRESERVATION

Methods. Wood Preservation (Osservazioni e proposte per la conservazione del legno), A. Sanna. Industria (Milan), vol. 44, no. 5, Mar. 15, 1930, pp. 124–127. Method described is economical and layer of permanent white formed on outside of wood prevents solutions of antiseptic substances from inner part of wood.

IN TWO SECTIONS—SECTION TWO

MECHANICAL ENGINEERING

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The Packard Laboratory

LABORATORY methods in the education of mechanical engineers in this country owe much to the pioneer work of Dr. Robert Henry Thurston, first president of the A.S.M.E., and well-known educator at Stevens Institute of Technology and Sibley College, Cornell University. Since Thurston's time educators have recognized the fundamental necessity of the laboratory method in engineering instruction, and, as a result, engineering laboratories and their equipment have received much attention and have developed tremendously. One of the most recent and finest laboratories for the study of engineering is to be dedicated at Lehigh University in October and is described in the October issue of MECHANICAL ENGINEERING.

The James Ward Packard Laboratory was the gift of the famous automobile manufacturer, a loyal Lehigh alumnus. The laboratory is to be devoted to mechanical and electrical engineering; its cost will be well over a million dollars; it embodies the most up-to-date principles in design, construction, and operation of such an educational plant.

Before President Richards of Lehigh knew where funds would be found to construct such a laboratory, he and his colleagues, convinced of the need for it, planned an ideal structure and issued an illustrated pamphlet to set forth their requirements. Mr. Packard's interest was aroused, and through his generosity the well-conceived plans became a reality. The article describing it, written by Professors F. V. Larkin and S. S. Seyfert, heads, respectively, of the mechanical and electrical engineering departments at Lehigh, relates the history of the project, describes the building, and discusses the principles involved in its design, construction, and operation.

da Vinci's Aerodynamics

PROBABLY the first man ever to give much serious and scientific thought to the problem of aerial flight, and to try to discover the fundamental laws concerning it, was Leonardo da Vinci, the versatile Florentine savant and artist. His manuscripts on details of his observations and studies date from 1482 to 1515. The results of da Vinci's investigations show that he had a remarkably comprehensive knowledge of the problems involved in flight by heavier-than-air machines. The principles formulated by da Vinci are briefly summarized in the October issue of MECHANICAL ENGINEERING by Prof. R. Giacomelli, of Rome, Italy. Professor Giacomelli, who is lecturer on the history of mechanics at the University of Rome, has collected the writings of da Vinci on the subject of aerodynamics and has edited them in the language of today so that they may be read without difficulty. It is hoped that an English edition of the book will soon make it possible for students of aerodynamics to become more familiar with da Vinci's remarkable investigations than is possible by a reading of the very brief summary published this month.

Plastic Molded Parts

THE materials which man has used since early times have been, as a rule, of natural origin. Stone, iron, wood, textiles lie ready for use, or are easily adapted to their uses by methods which were discovered ages ago. With the rise of modern chemistry, however, man has found it possible to devise from the most unpromising-looking ingredients, new materials which have interesting and valuable properties. Among these synthetic materials is a group of plastics that can be molded by means of heat and pressure into fairly intricate shapes. So rapid and widespread has been the introduction of articles made of such materials within recent years, that we are generally familiar with the uses and properties of them without knowing much about the technique and machinery of their manufacture. Certain non-metallic parts of telephone instruments, for instance, are handled by us daily. We recognize their beautiful finish, their light weight, their electrical- and heat-insulating properties, their resistance to discoloration and chemical attack, but what they are made of and how they are made, few—outside of those making similar products for other purpose—realize.

In the October issue of MECHANICAL ENGINEERING, A. M. Lynn, of the Western Electric Company, writes on the "Production of Plastic Molded Telephone Parts." He describes the hydraulic presses, auxiliary equipment, and tools used in the manufacture of certain plastic molded telephone parts that are made in large quantities. The materials described include phenol plastics, shellac, and hard rubber.

Education for Wood Utilization

WOOD has such abundant natural properties, is so readily available, and can be worked so easily that it has always been one of the most useful materials. Perhaps, also, these same features have retarded development of its greatest possible utilization in competition with other materials. While experts have studied iron and steel, for instance, with most amazing and profitable results, it has been rather generally assumed that the properties and technology of wood were too well known to need much serious scientific study. The adaptation of other materials to the purposes for which wood was originally used seemed fortunate in the light of dwindling forest resources. Conservation appeared to be the important problem, and study was largely devoted to silviculture.

But as the benefits of silviculture are reflected in more dependable resources, and as the replacement of wood by other materials continues to grow, a situation develops

in which we find wood losing ground even in applications such as furniture, where it had apparently been securely entrenched, so that the wood industries today view with alarm their vanishing markets.

To bring the wood-using industries to a par in their development with, for example, the metal-using industries can be accomplished by the same methods as were used with the latter. Technically trained men are needed for this development. They are needed as executives, as technicians, and as investigators or research workers, and it is the function of engineering and technical schools to train and provide them.

How this is done at the University of Michigan is told by Samuel T. Dana, Dean of the School of Forestry and Conservation, in an article in the October issue of MECHANICAL ENGINEERING.

Minimum-Cost Production

AFTER the technological problems of an industry are solved, economic production becomes of prime interest and importance, and the engineer must become an astute economist. He must decide whether he will manufacture ten or ten million of a given product, and in what size lots his manufacturing schedule will be split. He must decide how great an investment in time- and labor-saving machinery is justified, and countless other problems involving many technical and economic variables.

Prof. F. E. Raymond, of M.I.T., has been making a study of economic lot sizes, and has laid bare some facts on certain uneconomical aspects of minimum-cost production which he communicates to engineers and economists in the October issue of MECHANICAL ENGINEERING. Professor Raymond says that "In industries where intermittent processes predominate, it is possible to earn a larger annual return on each dollar invested when the quantity of any product which is processed at any one time is smaller than that for which the total unit cost of manufacture is a minimum, all other factors of business having been fully considered."

Small Manufacturing Plants

THOSE who heard the spirited presentation of the case for the small manufacturing plant made by Col. Crosby Field at the Spring Meeting, Detroit, Mich., of the A.S.M.E., at a session at which the relative advantages of small- and large-size manufacturing establishments were discussed, will agree that he championed his cause nobly. For those who were unable to hear his argument, an extended abstract of his paper is published in the October issue of MECHANICAL ENGINEERING.

A small plant, as Colonel Field defines it, is one employing less than 250 men, and 90 per cent of the manufacturing plants of this country fall into this category. Colonel Field divides the life history of plants into four critical periods: pioneer, expansion, consolidation, and disintegration. The only excuse for a plant supplying commodities to fulfil human needs, he says, is that it has selected a field for operations in which it has advantages which render it unique. This element of uniquity must be zealously maintained. In defending his advocacy of the small plant, Colonel Field discusses such problems of management as the characteristics of personnel, the type of organization, its dependence on specialization—and hence on research and development, and the distribution problem.

Standard Fits

STANDARD fits for cylindrical parts become necessary when a large number of components are made by mass-production methods for assembly into a product, and also when national standardization of tools and equipment, such as reamers and drill bushings, is undertaken. In 1925 the American Standards Association approved a Tentative American Standard on Tolerances, Allowances, and Gages for Metal Fits. Subsequently, with the formation of the International Standards Association, an international system of fits between cylindrical parts was studied by a subcommittee. This subcommittee has proposed an international standard based on the German system of fits which had been in use since 1920. The proposal is soon to be submitted to American industry by the A.S.A.

In the October issue of MECHANICAL ENGINEERING, John Gaillard, mechanical engineer of the A.S.A., who attended the Paris conferences of the I.S.A., held in May, 1930, gives a historical résumé of the development of the proposed system of fits and of the efforts which have been made to unify existing national systems. He compares the existing American system with the I.S.A. proposal and comes to the following conclusions:

1 The I.S.A. system of fits should be recommended to the attention of American groups.

2 It is desirable for American groups to participate in the work of the I.S.A. (The A.S.A. is a member body of the I.S.A.)

3 Study of the I.S.A. proposal may indicate the desirability of a review of the Tentative American Standard approved in 1925.

Strength of Welded Pipe Plugs

PLUGS for use in plugging pressure vessels and pipe lines are made by welding in two forms, i.e., hemispherical or orange-peel, and blunt or bonnet heads. In the first type, wedge-shaped pieces are cut at the end of the pipe plug, heated, bent until their edges come together forming a hemisphere, and joined by welding. In the bonnet head, V-shaped pieces are cut from the pipe end, and another section of pipe is cut to fit the pipe like a bonnet, the meeting edges being welded.

Some experiments were made to determine the relative strengths of these two types of plugs by Cornelius L. Hughes, who reports the results in the October issue of MECHANICAL ENGINEERING. The orange-peel head was found to be the stronger. With a medium welding rod and careful welding, an orange-peel head should sustain a circumferential stress of 55,000 lb. per sq. in., while a bonnet head should sustain a corresponding stress of 26,000 lb. per sq. in. With these stress values a factor of safety of at least 2 should be used to forestall possible variations in head shape, material, and welding.

Combustion Radiation

IN THE October issue of MECHANICAL ENGINEERING, Prof. Walter J. Wohlenberg continues his discussion, begun last month, of "Combustion Radiation and the Planck Quantum Theory." This month's instalment covers the laws of energy distribution and the distribution of the energy of combustion radiation. More next month.